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Growing seed

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THE WONDERFUL FRUIT PRODUCING ALCOHOLIC BEVERAGE FOR HUMAN AND ANIMALS

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Marula (*Sclerocarya birrea*) is taken into account to be the "Traditional Food Plant" of Africa. These trees are known by different names in several regions. A number of its common names include Morula, Jelly Plum, Cider Tree, Marriage Tree, Cat Thorn, Canhoeiro, Dania, Mutsomo, Mushomo and Umganu. Marula could be a medium sized tree. This tree is especially found in Miombo Woodlands in several regions of Africa. It's a deciduous tree belonging to a similar family (Anacardiaceae) as cashew, mango and pistachio. The fruits of this tree are the foremost source for "Amarula Cream Liqueur" and other alcoholic beverages. The nuts are consumed as seeds by humans and rodents.

Description of Marula Tree

This is a dioecious tree which suggests male and feminine flowers grow on separate trees. The feminine trees bear female flowers and fruits, while the male trees bear only male flowers. The crown of these single stemmed trees spreads during a good area. These trees have compound leaves consisting of seven to 10 small paired leaflets. The raw fruits are green, which turn yellow as they ripen. The white, juicy flesh features a novel flavour. The fruit is a drupe with a leathery epicarp, fleshy mesocarp (edible) and seed with hard covering (stone) endocarp. The buds of both male and feminine flowers are red. The marula inflorescence is a spiky, delicate flower of pink, lilac and white colour. The seeds of the Marula tree are situated inside the hard walled walnut sized stone. These edible Seeds are

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brownish with a tasty nutty flavour. The bark is irregularly spotted and freckled. They typically grow somewhere between 18m and 20m tall.

Uses of Marula

The fruits and nuts of those trees are used for various purposes.

Edible Usage

- The nuts, fruits and thus the extracted volatile oil have numerous edible uses.
- These fruits are used for preparing alcoholic drinks like beers and wines, including the famous South African "Amarula Cream Liqueur".
- These fruits also are used for preparing delicious jam, jelly and juice.
- The nuts of this tree prepare good snacks and are consumed raw or roasted.
- The nuts are utilized in many preparations for the aim of adding a special flavour to the food.
- The essential oil extracted from the seeds of *Sclerocarya birrea* is used as a highly nutritious oil.
- The skin of those fruits is dried, so on use it as a substitute for coffee.

Medicinal Usage

- Different parts, including the bark and thus the leaves of those trees, have some medicinal uses.
- The green leaves of this tree are believed to be ready to relieve heartburn.
- The Marula tree bark is used for the treatment of several diseases like diarrhoea, malaria and dysentery.

Other Usage

- These fruits are used as pesticides.
- The Marula oil is employed in natural therapies and for preparing cosmetic products.
- The wood of those trees is employed for creating furniture.

Products

- Amarula and Chocolate Covered Strawberries
- Amarula Mocha Truffles

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- Amarula Cheesecake
- Amarula French toast
- Salad with Amarula and topping
- South African Smoothie

Marula Side Effects

There are not any known side effects of those fruits or nuts. But sometimes nuts may cause allergies or allergenic reactions to parents that are allergic to nuts.

Marula Interesting Facts about these fruits

- They're a great favourite with an honest range of untamed animals, including elephants, monkeys, giraffes and wild boars.
- The foremost interesting thing about these fruits is that they become alcohol by undergoing fermentation within the stomach of the animals. As a result, the animals become drunk.
- The “Amarula liqueur” produced from these fruits is ranked third among the sole selling cream liqueurs.
- In certain communities, people store the nuts of Marula fruit to use them as an emergency food source. These nuts also are considered to be a mark of friendship by some people in Africa.

Growing Conditions

Soil: Sandy loam soil is true for these trees to grow properly.

Climate: Semiarid to sub-humid climates are ideal for these deciduous trees. But, they go to also survive in difficult climatic conditions.

Sunlight: Natural sunlight is sufficient for them. However, they need excellent resistance to harsh sunlight and warmth.

Water: Normal rainfall is required for their proper growth. The roots of Marula can store much water that keeps the trees alive even in draughts.

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Harvesting

The fruits ripen between the months of mid January and mid March and fall from the Marula trees as soon as they ripen and turn yellow. People collect the fruits from under the trees. The nuts are easy to gather once the outer shell is dry. Otherwise, one has got to break the outer shell so on urge the nut.

Conclusion

Marula fruit has been part of a supplemental diet in many African countries. Consumption of its leaves, fruits, and nuts is becoming very popular. Many products have been developed from different parts of the Marula tree for either medicinal or nutritional uses. Marula seed oil is a valuable source of essential fatty acids, phytosterols, phospholipids and tocopherols. The high levels of those bioactive lipids are of importance in nutritional applications. On the contrary, different parts of the Marula tree have significant effects on multiple biological systems.

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PAPAYA PRODUCTION TECHNOLOGY

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Papaya (*Carica papaya* L.) is widely grown in the tropical and subtropical regions in about 57 countries across the world. India, Brazil, Indonesia, Dominican Republic, Nigeria and Mexico are the leading countries in papaya production. India contributing 43.7 per cent to total world production, is the largest producer with 5.63 million tonnes (2013-14). It is widely grown in the states of Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, West Bengal, Chhattisgarh, Telangana, Tamil Nadu, Assam, Kerala and has emerged as a very remunerative commercial crop because of its early yields, high productivity, good nutritive value and availability throughout the year. It is grown for both fresh fruits and for papain extraction. Ripe fruits are very rich in carotenoids, precursors of Vitamin A (666I.U).

Soil and Climatic Requirements

Regions having summer temperature between 38 to 48^{0}C and where winter temperature does not fall below 5^{0}C are ideal for its growth.

Varieties

1. **Coorg Honey Dew:** It is a gynodioecious, semi dwarf selection from Honey Dew used for both table purpose and papain extraction. Fruits are big, weighing 1.75 to 2 kg, dark green in colour with the slight ridging skin surface, elongated and oval from hermaphrodite trees and ovoid from female trees, with 13.5^0 Brix TSS, yellow pulp, large cavity and poor keeping quality.

2. **Pusa Giant:** It is a dioecious selection developed by sib mating the variety Ranchi. Plants are highly vigorous, bearing first fruit at one meter height and can stand the storm and windy conditions well. Fruits weight 2 to 3 kg with yellow, moderately firm

5 cm thick pulp having 7 to 8.5^{o}Brix TSS and 18 x 10 cm cavity. It yields about 40 kg/plant.

3. **Pusa Nanha:** It is a dioecious dwarf mutant having 106 cm height, bearing fruit at 30 cm height suited for high density planting (6.400 plants per hectare) and pot cultivation and tolerant to water logging. Fruits are medium sized, round to ovate in shape with thin, yellow pulphaving/plant.

4. **Arka Surya:** It is an advanced generation hybrid from the cross Sunrise Solo x Pink Pulp Sweet. The fruits are medium sized, weighing about 600-800g with good keeping quality. The pulp is deep pink and firm with 13-14°Brix TSS. Fruit yield is 60 - 70 kg/plant for 28 months cropping period.

5. **Arka Prabhath:** It is an advanced generation hybrid from the cross (Surya x Tainung-1) x Local Dwarf). The fruits are big sized, weighing 900-1200 g, firm and deep pink in colour with TSS of 13-14^{o}Brix and good keeping quality. The average yield is 90 - 100 kg /plant.

6. **CO 8:** This is a red pulp dioecious variety developed by initial selective hybridization of CO.2 (yellow pulped) with red anthered male followed by intermating and repeated selection in segregating population for red pulp colour. Fruits are suitable for dessert purpose, pulping, processing (RTS, jam, tutti-fruity) and papain industry (Papain activity 138TU/mg). The fruits are big, oblong, weighing an average of 1.5-2.0 kg/fruit with a TSS of 13.5% with a prominent apex. The tree can be economically maintained for 20-22 months under a favourable condition with a yield potential of 230 t/ha when planted at a spacing of 1.8 x1.8m.

Propagation

Papaya is generally propagated by seeds obtained through controlled pollination. The seeds lose viability very fast if stored with high moisture content or if sun dried. The seeds show orthodox storage behavio**u**r. Seeds dried to a moisture content of (6 to 8%) and packed in moisture impervious container like poly lined alumin**i**um pouch with airtight sealing can be stored at ambient conditions for short term storage (18 months) and at 15^{o}C for medium term storage (2-3 years). Treating the seeds with 100 ppm GA for 8 hours enhances germination. Seeds are sown in perforated polythene bags measuring 20 X 15 cm size with 150 gauge thickness, filled with equal proportions of farmyard manure, red soil and sand. Arka microbial consortium @ 1 to 2 per cent (1 to 2 kg for 100 kg potting mixture) may be added for healthy seedling production. Two seeds are generally sown in each bag. The best time for raising the seedling is between June to October. In eastern parts of the country, seeds are usually sown from March to May so that the seedlings are ready for transplanting before the onset of the monsoon. In North India, where frost is common, seeds are sown between February and April. Seeds germinate in about 2 to 3 weeks time, depending on the temperature. In the case of dioecious varieties, about 100 g of seeds and in the case of gynodioecious varieties, 30 to 40 g of seeds are required per acre. Generally, 45 to 60 days old seedlings are preferred for planting.

Spacing and Planting

In the main field, pits of 45 cm^3 are dug at the spacing of 1.8m X 1.8m, which should be filled with red earth and FYM. Arka Krishi All Rounder Talk formulation @ 2-3 kg/one ton of FYM or 2-3 litres of liquid formulation/one ton of FYM may be enriched. This enriched FYM may be applied @ 5 kg/plant at the time of planting and repeated at six months interval @ 2 kg/plant for growth promotion and yield enhancement. Instead of pits, trenches can also be dug. In the case of dioecious varieties, three plants are planted per pit so that early flowering males are removed to maintain one male plant for every ten female plants.

Nutrition and Integrated Nutrient Management

For papaya, fertilizers should be applied once every two months. Although fertilizer application in a particular region depends on the soil and leaf analysis, generally 90 g of Urea, 250 g of Superphosphate and 140 g of Murate of Potash per plant are recommended for each application. The total requirement is 250 g N + 250 g P_2O_5 + 500 g K_2O per plant/year. Application of 7-10 kg farmyard manure/plant every six months is recommended in addition to fertilizers.

Irrigation

Irrigation should be given at weekly interval during summer and once in 8-10 days during the winter season. The orchard should have a good drainage system as the crop is susceptible to waterlogging. Ring and drip irrigation are the preferred methods of irrigation.

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Drip irrigation with 80% replenishment of evaporation losses is recommended. During the summer months, the plants should be given 20-25 L of water and can be gradually reduced to 10-15 L of water/plant in winter.

Integrated Pest and Disease Management

Stem rot or foot rot (*Phytophthora spp., Phythium aphanidrmatum, Rhizoctonia solani*) : Water-soaked patches on the stem at ground level, which enlarge and girdle the base of the stem develop. The affected tissues turn brown than black and rot. The terminal leaves turn yellow, wilt and drop. Fruits, if formed, also shrivel and drop off. The entire plant topples and dies because of the disintegration of parenchymatous tissue. For its management, Seed dressing with Captaf (Captan) or Chlorothalonil (Kavach) should be done before sowing the seeds. The soil at the orchard should be well drained. Before planting, application of Neem cake + *Trichoderma harzianum* should be provided. Healthy nursery plants should be planted and crop rotation with non host crop should be followed. Soil drenching with tridemorph (Calixin 0.1%) or metalaxyl + mancozeb (Ridomil MZ 0.2%) or chlorothalonil (Kavach 0.2%) at bimonthly interval provide effective control of the standing crop. **Damping off** (*Pythium, Phytophthora, Rhictonia* and *Fusarium*spp.)

Pre emergence damping off : Characterized as the toppling of the growing tip before it comes out of the soil.

Post emergence damping off: Seedlings show pale withering and bending symptoms near the ground level with the severe girdling of the stem tissue. In the case of *Phytophthora* and *Fusarium,* root rot is also observed. Such affected seedlings suddenly topple down.

Seeds for raising nursery should be obtained from healthy fruits. Water stagnation and low lying areas should be avoided for the nursery. Seeds should be treated with oxycarboxin (Vitavax), carbendazim SD, captaf (Captan), Tthiram @ 2 g/Kg seeds. Soil amendments with solarization, application of neem cake + *Trichoderma harzianum,* Dazomet, Formaldehyde should be practised. Drenching of Nursery with chlorothalonil (Kavach 0.2%) or oxycarboxin (Vitavax 0.1%) or carbendazim (Bavistin 0.1%) should be done.

Anthracnose (*Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.): Disease can attack fruits petioles, leaves, floral parts, etc. Water soaked spots first appear as superficial brown discolouration of the skin and then develop into circular, slightly sunken areas 1-3 cm diameter. Gradually the lesions coalesce, and sparse mycelial growth often appears on the margins. Under humid conditions, encrustations of salmon pink spores often arranged in a concentric pattern develop on the surface of older spots. Fruits later turn dirty brown and rot. Infection at early stages results in mummification and deformation of fruits, whereas at the mature stage, soft rot develops. Sometimes Chocolate unsunken brown lesions appear on the ripening fruits. The petioles of the lower leave dry and are shed. To control it, Infected leaves should be removed and destroyed. Spraying of mancozeb (Dithane M 45 0.2%) or chlorothalonil (Kavach 0.2%) or carbendazim (Bavistin 0.1%) at 15 days interval provides effective control. Dipping fruits in water at 46 to 49°C for 20 minutes shortly after harvest provides control of disease under storage.

Powdery mildew (*Oidium caricae*(Noack.): Small circular powdery patches develop on both the sides of leaves and on stem of young seedlings. These patches gradually extend, coalesce and cover the entire leaf surface. Badly infected leaves curl, dry, hang down and ultimately fall off. Young seedlings may die under severe disease attack. Sometimes in severe cases, the pathogen attack fruits also. The disease is effectively controlled through the spraying of wettable sulphur (Sulfex 0.3%) when the atmospheric temperature is below 30°C. Application of systemic fungicides, namely tridemifon (Bayleton 0.1%) or carbendazim (Bavistin 0.1%) or thiophanate methyl (Topsin M or Roko 0.1%) at monthly interval is much more effective.

Ringspot virus (PSRV): Papaya ringspot disease is also known as papaya mosaic, papaya distortion mosaic, mild mosaic, papaya ringspot, papaya leaf reduction, thin leaf and distortion as all the above symptoms are caused due to Papaya ringspot virus. The typical mosaic caused by potexvirus so far not found in India.

PRSV-P strain naturally infects papaya and cucurbits. Plants of all ages are susceptible, and symptoms are generally more severe during cooler weather. The disease derives its name from the characteristic dark green sunken rings that develop on the fruit of affected plants. These rings often persist as dark orange to brown markings as the fruit matures. Dark green, water-soaked streaks develop on petioles and stems. Mottle and mosaic patterns of varying severity develop on leaves that often have a ruffled appearance. One or more leaf lobes may become stunted, and the fruit set is markedly reduced or absent. Fruit from affected plants have poor flavour, a leathery appearance and are predisposed to fungal fruit rots. Growing of border crops *viz.*, two rows of Sesbania or castor 15 days before planting of papaya, rouging and removal of early infected plants as when noticed helps to control the disease incidence. Several cultural practices have proven useful in slowing epidemics and reducing crop damage. Establishing plantations with seedling plants free of PRSV-P is essential, and new planting should be situated as far as possible away from affected plantations. Plantations can be surrounded by non-host crops or interplant with other tree crops. Growing tolerant or resistant varieties is the best option. Genetically engineered resistance against PRSV has been achieved in Hawaii using Kapoho, Sunup and Rainbow cultivars. However, in India so far PRSV resistant cultivar, However, in India so far PRSV resistant cultivar is not available at present. Efforts are underway to develop PRSV resistant/tolerant types by crossing the commercially grown papaya varieties with wild species of *Vasconcellea.*

Insect Pests

The important pests are Red spider mite and root-knot nematodes. The mite infestation becomes severe during summer, and spraying dicofol @ 2.5 ml /L water on the ventral side of the leaf can control it. Applying 25 g Carbofuran/plant in the main field can control nematodes.

Harvesting and Yield

Harvesting generally starts 9 to 10 months after sowing. Mature fruits are harvested when they show streaks of yellow colouration. Since papaya trees are not very tall, handpicking is employed. Yield in papaya varies from about 25 kg/plant in some varieties like Solo to 75 - 100 kg/plant in varieties like Coorg Honey Dew, CO varieties and Arka Prabhath. It also varies from region to region and with cultivation practices. The economic yield in papaya is for a period of three years.

Conclusion

General neglect and non-adoption of scientific cultivation practices are the major constraints for poor return from papaya cultivation in the region. It includes a proper planting system, excessive intercropping of exhaustive nutrient crops like turmeric, ginger, no use of soil and water conservation measures, nutrient application and plant protection measures.

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There is no separate package of papaya cultivation practices in the northern region particularly, but only general recommendations have been made in combination with other fruit crops. There is also a general lack of awareness among the growers about the production technologies, and this is perhaps one of the important factors responsible for the low productivity of papaya in the region.

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Hand Book of horticulture

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SOIL HEALTH CARD: A LIFE FOR SOIL

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According to the latest estimates, 96.40 Million Hectare (Mha) area of India is undergoing the process of land degradation, which is 29.32 per cent of the Total Geographic Area (TGA) of the country during 2011-13 it was 94.53 Million Hectare in 2003-05 (GoI 2016). It is not a good sign for soil health. The states of Rajasthan, Maharashtra, Gujarat, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana contribute 24 percent of the degraded area in the country. In India, the current consumption of NPK ratio is 6.7:2.4:1, which is highly skewed towards nitrogen as against the ideal ratio of 4:2:1. Hence, there is a need for balanced use of fertilizers. According to the "Degraded and Waste Lands of India" report by the Indian Council for Agricultural Research (ICAR) and the National Academy for Agricultural Sciences, 141 million hectares of the total geographical area of India, which is about 328.2 million hectares, is 70 per cent of total cultivation which is 100 million hectares is heading down a path where it will be incapable of supporting farming. Farmers are using soil more and growing crops more than two times a year without proper soil management. Soil health and fertility is the basis for the sustainable profitability of the farmers. To keep all thing in mind, the ministry of agriculture has introduced the Soil Health Card (SHC) scheme on world soil day, 5th December 2015. The scheme is an improvement over the earlier National Project on Management of Soil Health and Fertility that was launched during 2008-09. To achieve eco-friendly agriculture, the soil must be good preserve and of good quality (Calleja-Canvantes*et al.*, 2015). Soil health card scheme helps farmers know about the crops that can be planted depending on the soil based on scientific method. By doing this, the farmer can get maximum yield while harvesting the crops. SHC help to get to know soil quality. Soil quality defined as the capacity of soil to function within boundaries of natural and maintain plant and animal growth and also maintain water and air quality and also should not any side effect on human health (Karlen et al.,1997)under this scheme based on analysis, the farmer is provided with a soil health card that determines the crops that can be cultivated on the particular soil and measure to develop the productivity of the crops. In Cycle-I (2015-2017) 100 million soil health card distributed and 4.71 crore soil health cards have been distributed to the farmers all the country during cycle-II which cover 2017 to 2019.

Soil health card contains the following details

- The health of the soil
- Functional characteristics of the soil
- The water content and nutrients present in the soil
- Additional properties of the soil
- Measure to improve the defects of the soil

Benefits of the SHC

1. The farmer will be notified about the soil type according to soil type they can plant crop.
2. The authorities provide a report to the farmers once in three years after observing the soil regularly. This will help farmers not worry about the cultivation of crops in case of soil change due to natural factor.
3. The farmers are also given advice by the experts according to their soil sample result about improve the productivity of the crops and the necessary methods that have to be practised in order to implement the changes.
4. Soil health card contains the status of soil with respect to 12 parameters, namely N. P. K.(Macro-nutrients), S (secondary nutrients), Zn, Fe, Cu, Mn, Bo (Micronutrients) and pH, EC, OC (Physical parameters) based on this, the SHC will also indicate fertilizer recommendations and soil amendment require for the farm.
5. The farmers will be informed about the needed nutrients in the soil after analysis in the laboratory which nutrients have poor in their soil.

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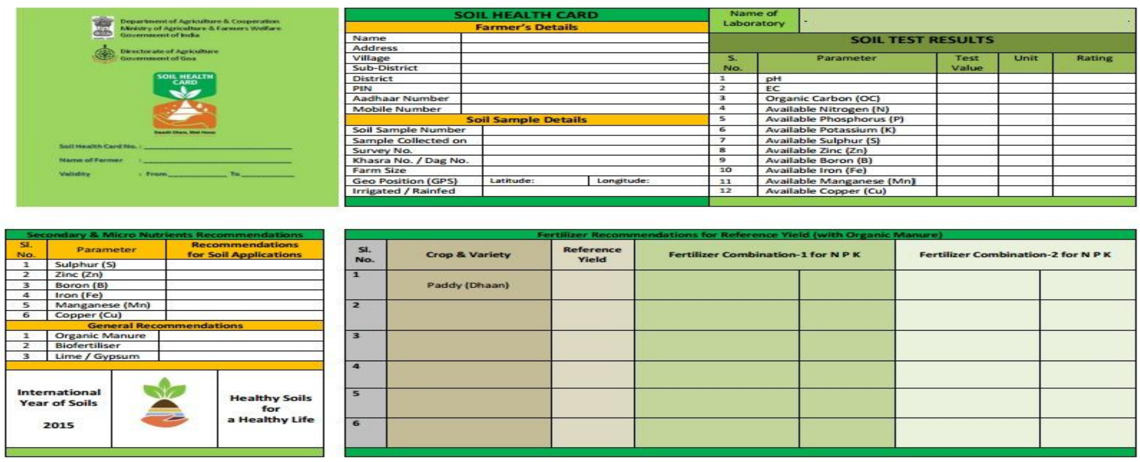
Testing of the soil

Soil sample is taken twice regularly in a year after the harvesting of the Rabi and Kharif crops and also can collect a sample when there is no crop in the field. The samples will be collected by the experts where the soil will be cut with the help of a spade or require a tool to adapt of 15-20 cm in a **'V'** shape. Sample should be collected from four corners of the field and the centre of the field and mixed thoroughly and a part of this picked up as a sample. The collected sample will be bagged and coded. The obtained sample will be coded and then sent to laboratories for conducting tests and analysis.



Conclusion

The main reason behind the soil health card scheme. This card helps to identify the scarcity of any elements which are responsible for the slow growth of crop so farmers could recognise the main problems in the soil through this SHC and can solve it.

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SPEED BREEDING: A FASHIONABLE BREEDING APPROACH

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The global population is said to reach 9 billion by 2050 and will strain the resources. Rapid climate change and the emergence of new pests and diseases threaten agricultural production. Thus, producing a higher amount of quality food for the ever-increasing population is a major concern today. Moreover, the amount of genetic gain has to be raised further than the levels presently achieved by the conventional breeding programs Lin *et al.,* (2016). New and innovative methods are the prime requirement now. Speed breeding is such a tool or technique for rapid generation advance that significantly reduces the harvest time of crops in order to speed up agricultural research and increase the production of food to meet the demand of the growing population Sankar *et al.*, (2020).

Speed breeding was first initiated by NASA targeting to raise wheat in space using extended photoperiods or constant light and precise temperature in order to overdrive photosynthesis and hasten plant growth (https://www.thehindubusinessline.com). Dr Lee Hickey and his co-workers were the first to adopt NASA'S Plan for the production of wheat and peanut at the University of Queensland, John Innes Centre and the University of Sydney in Australia.

The experiments done on wheat revealed that the yield and the quality of plants grown under controlled climate with extended daylight were the same as those of crops grown in regular glasshouse conditions Shivakumar *et al.*, (2018). Traits that we can measure using speed breeding are: Green Revolution dwarfing genes, Awn suppressor genes, Fusarium head blight resistance, Rust resistance, Glaucousness, and Tan spot resistanceTarek*et al.*, (2018).

Methods of Speed Breeding (Watson *et al.*, 2018)

1. Speed Breeding I – controlled environment chamber conditions (John Innes Centre, UK)

- Photoperiod : 22Hrs (light)/ 2Hrs Dark
- Temperature: 22°C (photoperiod)/ 17°C (Dark)
- Humidity: 70%
- Light: white LED, far-red LED & Ceramic metal hydrargyrum quartz iodide lamp
- Light Intensity: 360–380 µmol m^{-2} s^{-1} (highest value after ramping) at bench height and 490 – 500 µmol m^{-2} s^{-1} (highest value after ramping) at adult plant height (with reference to wheat, *T. aestivum* cv. Paragon)

2. Speed Breeding II – glasshouse conditions (Hickey Lab, Univ. of Queensland, Australia)

- A temperature-controlled glasshouse fitted with high pressure sodium vapour lamp
- Photoperiod: 22Hrs (light)/ 2Hrs Dark
- Temperature: 22°C (photoperiod)/ 17°C (Dark)
- Humidity: 70%
- Light Intensity: 440-650(Adult Plant height) µ mol m^{-2} s^{-1} (approximately 45cm above bench height).

3. Speed Breeding III- low-cost homemade growth room design (Hickey Lab, of Queensland, Australia)

- Photoperiod: 12Hrs-12Hrs (Light-Dark) for four weeks then increased to 18Hrs-6Hrs
- Temperature: 21°C (photoperiod)/ 18°C (Dark)
- Light: 7 -8 LED light boxes (Grow Candy)
- Intensity:210–260 (bench height) & 340–590 (Adult Plant height) µ mol m^{-2} s^{-1}

Advantage of Speed Breeding

1. Multiple generations in one year
2. Fast way to obtain fixed homozygous lines through Single Seed Descent method
3. Phenotypic selection in early segregating generations
4. Rapid introgression genes into elite lines using Marker Assisted Selection
5. Allows study of plant-pathogen interaction, flowering time etc.
6. Multi- environmental trail across years

7. Integrated with genomics selection, genome editing etc.
8. High – throughput phenotypic screens for multiple traits
9. Exploit gene bank accessions and mutant collection for rapid gene discovery

Limitation of Speed Breeding

1. Extended photoperiods may cause injury in some crops
2. Unlikely to be successful in short-day crops
3. Disease outbreak using controlled environmental conditions
4. Plant losses in Single Seed Descent during greenhouse condition
5. Increased monetary costs
6. Incorporation of relatively simple inherited traits

Achievements

By speed breeding program, growing up to six generations per year is possible in wheat, barley, chickpea and up to four generations of canola Acquaah*et al.,* (2012). Speed breeding is also applied in pea, peanuts, grass pea, amaranth, quinoa, *Brachypodium, Medicago* and many more crops. The technique is responsible for the development of 'DS Faraday' wheat variety, which is a high protein, milling wheat with tolerance to pre-harvest sproutingTarek *et al.,* (2018).

'Scarlett' is the most extensively cultivated cultivar of barley in Argentina, which is susceptible to many diseases. By taking four lines with a modified backcrossing method, resistant lines were developed within two years Hickey *et al.,* (2017). Moreover, drought tolerance trait in barley can also be achieved by speed breeding Ghosh *et al.,* (2018).

'YNU31-2-4', a Salt tolerant rice variety, was developed with the help of speed breeding. The gene was inserted by SNP marker, and the breeding cycle accelerated by speed breeding (14h light/10h dark- germination to 30 days of germination, ten h light/14h dark-reproductive phase). The tillers were removed, and the embryo rescue technique was used to save time before seed maturity. Thus, enabling the researchers to get 4 to 5 generations of rice per year Rana *et al*., (2019).

Speed breeding surpasses "shuttle breeding" and produces three times a greater number of generations. With shuttle breeding, only two generations per year can be achieved, while with speed breeding, up to 6 generations can be obtained Ortiz *et al*., (2007).

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Conclusion

The breeding program should be at par with changing climate, and breeding for resilient climate crops is the immediate challenge that can be accomplished through the new ideas of speed breeding. Speed breeding can be considered an effective tool to achieve the 2050 genetic gain targets for the four Fs (Food, Feed, Fibre and Fuel). Speed breeding combined with new technologies like marker-assisted selection, genomic selection, CRISPR gene editing etc., can be used to get the end result much faster. In-country like ours, where resources are very limited, speed breeding can be one of the most viable options to shortening the breeding cycle and accelerating the research program.

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BALANCED NUTRIENT FERTILISATION: AN APPROACH FOR AGRICULTURAL SUSTAINABILITY

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The green revolution was the thumping milestone for self-reliance in the food security of the country. Major contributing factors in this green revolution involved high yield varieties, fertilisers, and the irrigated area's expansion. Those high yielding varieties were highly responsive to the added nitrogenous fertiliser, which led to higher production. Indian soils were fertilised with organic manures and farmyard manures during that era which stabilises soil health. However, with the beginning of intensive cultivation, the nutrient status of the Indian soils started depleting. The application of nutrient fertilisers shows synergistic and antagonistic effects on plants growth, development and crop yields. The synergistic effects of the different nutrients lead to higher uptake of other useful nutrients. The antagonistic effect shows the detrimental effect of an applied nutrient on the uptake of the other nutrients. The lack of established nutrient management strategies and poor knowledge of the farmers pertaining to balanced nutrient fertilisation were the two critical factors for declining productivity under intensive cultivation. For most of the Indian soils, ideal nutrient application ratio of N: P_2O_5:$K_2O$is 4:2:1; this gap widens from 4.7:2.3:1 in 2010-11 to 6.6:2.6:1 in 2018-19(FAI, 2019). The ratio is indicating that the nutrient imbalance is increasing in Indian soils. Apart from the imbalanced NPK fertiliser applications and less use of farmyard manure or compost causes multiple nutrient deficiencies, which includes P, K, S, Zn, Mo, Fe and Mn in different parts of the country.

Fig 1: Nutrient deficiency in wheat plants due to imbalanced fertilizer application

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Balanced fertilisation

In a particular agro-climatic condition, the application of plant nutrients in optimum quantities with appropriate method and appropriate time to meet the demand of the specific crop for its optimum growth, development, and productivity can be termed as **balanced nutrient fertilisation**. Balanced nutrient fertilisation improves the soil's physical, chemical, and biological environment, whereas underbalanced nutrient fertilisation leads to soil sickness and the uneconomic waste of scarce resources. For a sustainable and productive land-use system, balanced nutrient fertilisation is essential for continuous food grain production.

Concept of Balanced Nutrient Fertilisation

In 1840, Justus von Liebig introduced the term **balanced fertilisation** which was mainly based on minimum law. According to this law, the plants' growth and development depend on the amount of the nutrients whose quantity is less than the plant's requirement keeping all other essential nutrients in optimum amount. Hence, balanced nutrient fertilisation is not limited to the application of NPK fertilisers only. It also includes the application of farmyard manure/organic manures to meet the demand of other essential nutrients by the crop plants to ensure:

- Efficient use of applied fertiliser
- Development of the best positive and synergistic interactions amongst the various other factors of production.
- For improving/ sustaining the soil productivity.
- Minimising the difference between potential yield and actual yield of a crop variety.
- Minimising environmental pollution.

Effect of Unbalanced nutrient fertilisation on agriculture

The adverse effects of unbalanced nutrient fertilisation can be broadly divided into three groups:

1) Effect on soil fertility
2) Effect on crop productivity
3) Effect on animal productivity and health

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1) ***Effect on soil fertility***

The unbalanced nutrient fertilisation induces deficiencies and toxicity of nutrients in the soil in response to positive and negative interactions between the nutrients, according to Annual Reports on AICRP-IFS under the different nutrient management practices. The fertility status of the soils was in declining order after 25-30 years after intensive cultivation. In different soil, increased deficiency of P, K, S, Zn and Mn were reported. Several researchers documented that increased application of phosphorus induces iron deficiency; increased application of zinc induces iron deficiency or vice-versa. In some acidic soils, excess ammonical fertilisers promote the protons release in soil solution through plants. Thereby, the growth medium becomes more acidic with more iron availability for the plants, which may cause iron toxicity. Nitrate fertilisers increase the pH of the soil, which leads to the deficiency of iron for plants. Balanced fertilisation also affects the soil microbial population.

2) ***Effect on crop productivity***

The different nutrient plays different roles in improving crop productivity. Nitrogen imparts soft tissue, and potassium imparts disease resistance to the plant. Excess nitrogen applications lead to more softness in plants, whereas low potassium application results in a decline in disease resistance in plants, which makes more favourable conditions for fungal infection and insect infestation, which ultimately results in reduced crop productivity. Lack of micronutrients in the soil for the crops results in stunted growth, twisting/curling of the leaves etc., which in turn affect the plants' photosynthetic potential. This reduction in photosynthesis leads to a reduction in crop productivity.

3) ***Effect on animal productivity and health***

The agricultural animal, which includes cows, buffalos, sheep, goats, pigs, and poultry, primarily depends upon crops for their feed and fodder requirements. The cultivated fodder and feed from the nutrient-deficient soils could not supply adequate nutrients and minerals to animals. For example, the deficiency of calcium or phosphorus in the feed and fodder may weaken the bones of the animals. Again, low potassium in feed/ fodder of animals may disturb water balance, osmotic pressure, acid-base balance, activations of the enzymes,

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metabolising carbohydrates and proteins, and neuromuscular regulation activity (along with Ca) and also the regulation of heartbeat. In some cases, lack of adequate nutrient balance in animal rations leads to infertility and poor health in productive animals.

Role of Balanced Fertilisation

Balanced fertilisation improves the physical, chemical, and biological environment of the soil, increasing crop yields. It also plays a significant role in making plants more tolerant to drought, cold, insects, pests and diseases. In recent years, balanced fertilisation increased wheat and corn yields in China by 15-20% (Cisse, 2007). Besides optimum crop production and better food quality, balanced fertilisation is the best solution to minimise the risk of nutrient losses. If applied nutrients are not balanced, the crop will not show its proper growth, and the overall uptake of nutrients will be affected. Thus, the applied nutrient will not be adequately utilised by the crops. They will be accumulated in the soil, which leads to environmental problems. Balanced fertilised crops provide an adequate amount of nutrients for the livestock, which improves their health and productivity. Balanced fertilisation is a sustainable approach to get maximum economic benefits from high crop yields with efficient soil nutrient reserves maintenance.

Benefits of Balanced Fertilisation

1. Balanced fertilisation improves and enhances soil fertility by replenishing the nutrient in the soil.
2. Combined organic and inorganic fertilisers can only take potential benefits from high yielding varieties approach in a balanced manner. High yielding varieties cannot produce satisfactorily without the use of proper doses of nutrients. Studies confirmed that in the green revolution, the contribution of varieties also increased rice yield was 27 Mt, and the fertiliser contribution was 29 Mt (Pinstrup-Anderson and Hazell, 1985).
3. Balanced fertilisation increase the yield and biomass production of crops in nutrient-poor soils of tropical areas. Additional biomass can be incorporated into the soil to improve organic matter content, significantly improving soil moisture retention capacity and enhancing nutrient use efficiency. Thus in nutrient-poor soils, balanced fertilisation can create a 'win- win' situation by increasing food production and reducing soil degradation.

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4. Indian soils are mainly deficient in S, Zn and B, and if these nutrients are applied adequately in soil, then the efficiency of NPK will also be increased significantly (Sakal*et al.*, 2006).

How to Make Use of Balanced Fertilisation

1) Applications of the recommended dose of fertilisers

Three concepts are used for making fertiliser recommendations,*i.e.*, Maintenance concept, Cation-Saturation ratio and Sufficiency level. Among the three of them, the sufficiency level concept is followed mostly for fertiliser recommendations. Insufficiency level concept, crop response is considered for applying nutrients for the crops. Fertiliser recommendations also vary with different varieties of the same crop. Therefore, fertiliser recommendations are also provided with the package and practices of newly released varieties. Some general recommended dose of nutrients for different crops is given in Table 1.

Table 1: General recommended dose of fertilisers for various crops grown in India

Crop name		NPK Recommendation (Kg/ha)		
		N	P_2O_5	K_2O
Cereals	Rice	120-150	40	20-40
	Wheat	120-150	60	40-60
	Barley	60-80	30	-
	Maize	80	40	20
	Sorghum	80-100	40-50	40-50
Oilseeds	Rapeseed and Mustard	120	30-50	20-40
	Groundnut	40-45	20-30	40
	Soybean	20-30	60	30-40
	Safflower	60	25-40	-
	Sunflower(Short duration)	30	40	30
	Sunflower(Long duration)	60	80	60
	Linseed	40	30-45	30-40
	Sesame	20-50	40	15-30
	Castor	45	60	-
Legumes	Pigeon pea	15-25	60-80	20
	Green gram	10-20	40-60	20
	Black gram	10-20	40-60	20
	Cowpea	20-30	40-60	40-60
	Horse gram	20	30	-
	Moth bean	10-20	40	-
	Chickpea	15-20	40-60	20
	Cluster bean	20	50	-
	Lentil	10-25	30-60	20
	Field pea	20-40	50	20

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	French bean	90-120	60	-
	Lathyrus	10	40	-
	Hybrid cotton	120-150	60-75	60-75
	Cotton (North India)	80-100	30-50	-
	Jute	60	30	30
Fibre crops	Mesta	60	30	30
	Sunhemp	20	40	40
	Sorghum (Two cuts)	60 (Basal) 50 (After cut)	60	60
	Pearl millet	50 (Basal) 30 (After 1month)	30	30
	Maise	80-100	40	-
	Teosinte	60 (Basal) 30 (After one month)	30	-
	Oats	120	40	-
Fodder crops	Guinea grass	60 (Basal) 40 (After each cut)	50	40
	Napier-Bajra Hybrid	60 (Basal) 30 (After each cut)	50	40
	Setaria grass	40 (Basal) 20 (After each cut)	40	40
	Para grass	40 (Basal) 40 (After each cut)	50	50
	Rice bean	20	50-60	-
	Berseem	20	80-90	30-40
	Lucerne	20	60-75	40
	Sugarcane (North India)	120-150	80	60
	Sugarcane (South India)	250-350	100	80
Cash crops	Potato	120	80	100-120

Courtesy: Prasad, 2002

2) Use of Customised fertilisers

Customised fertilisers are multi-nutrient carriers containing macro and micronutrients for satisfying the crop needs that are site-specific and validated by scientific crop model. It is the emerging concept based on the balanced nutrient fertilisation approach to address the crops' multiple nutrient needs. The customised fertilisers are manufactured by different macro and micronutrient combinations such as sulphur, zinc, and boron combined to the urea, DAP and potash in a proportion that will be able to fulfil the crop demand.

3) Integrated nutrient management approach

Neither application of chemical fertilisers alone nor the application of organic matter alone can meet all the crops' requirements. Crops do not only need significant nutrients (N, P and K) alone; they also require micronutrients and trace elements in smaller amounts. The intensive cultivation leads to a decline in the soil carbon status, resulting in a decline in the nutrient and water holding capacity of the soils. Hence it is required to manage all the nutrients in an adequate amount and enrichment of soil carbon. The addition of organic matter helps improve soil quality to sustain biological productivity, maintain environmental quality and promote plant and animal health. Hence, integrated nutrient management combines economic, efficient traditional and improved technologies from the symbiosis and synergy of crop-soil environment bio-interactions. Integrated nutrient management is the most logical way of managing long term soil fertility and productivity. Integrated use of organic manures, chemical fertilisers, crop rotations, and crop residue incorporation has been found promising in arresting the decline in productivity through increased fertiliser use efficiency and correcting marginal deficiencies of secondary and micronutrients and their beneficial influences on the physical and biological properties of the soil. Integrated nutrient management can bring about equilibrium between degenerative and restorative activities in the soil environment.

4) Soil test based fertiliser recommendation

In this approach, the soil is tested for different nutrients such as N, P, K and their status in the soil where the soil is categorised into low, medium and high fertility classes. The state-level fertiliser recommendations for a particular crop and variety are given from time to time in the package and practices of different seasonal crops, meant for medium soil fertility classes. If the soil tests result shows low fertility status for any particular nutrient, then the dose for that nutrient has to be increased by 25%, and if the soil tests result show high fertility for any nutrient, then the dose for that nutrient has to be decreased by 25%. With the recent Soil Health Card initiative by the Govt of India for the farmer's field, farmers are recommended optimum doses of fertilisers and manures to maintain good soil health.

5) Soil test crop response approach

Recommendation from this approach is specific to a given type of soil, crop and climatic situation. This contribution of soil available nutrient and yield level needs to be taken into account for recommending fertiliser dose for a particular crop. This approach is also known as prescription based fertiliser recommendation. Three essential parameters are worked out for the fertiliser recommendations:

- $\boldsymbol{Nutrient\ requirement}\ \left(\frac{\boldsymbol{KG}}{\boldsymbol{q}}\right) = {Uptake\ of\ nutrients\ \left(\frac{Kg}{ha}\right)} \Big/ {Grain\ yield\ \left(\frac{q}{ha}\right)}$

- $\boldsymbol{Efficiency\ of\ soil\ available\ nutrients}\ (\boldsymbol{CS}\%) =$

$$Uptake\ in\ control\ plot\ \left(\frac{kg}{ha}\right) \Big/ Soil\ test\ value\ of\ nutrient\ \left(\frac{kg}{ha}\right)\ in\ control\ plots\ x\ 100$$

- $\boldsymbol{Efficiency\ of\ fertilizer\ nutrient}\ (\boldsymbol{CF}\%) =$

$$Total\ uptake\ in\ fertilized\ plot - (STV\ in\ fertilized\ plot\ x\ CS) \Big/ Nutrient\ applied\ through\ fertilizer\ x100$$

6) *Diagnosis and recommendation integration system*

In this approach, plant samples are analysed for nutrient content, and they are expressed as ratios of nutrients with others *viz;* N/P, N/K, P/K etc. Suitable ratios of nutrients are established for higher yields from experiments and plant samples collected from farmer's fields. The nutrients whose ratios are not optimum for high yields are supplemented by top dressing. This approach is generally suitable for long-duration crops, but it is tested for short duration crops like soybean, wheat, etcetera.

7) *Site-specific nutrient management (SSNM)*

The optimal and supplemental application of nutrients to meet the plants' temporal and spatial needs at a specific site is called site-specific nutrient management. It is an approach for need-based 'feeding' of nutrients to the crops. It allows optimum use of existing nutrients such as soil reserves, residues and manures. It ensures to management of soil nutrient variations throughout a field with prescription fertiliser application. This approach involves three steps:

Step 1: Establish an attainable yield target

Step 2: Effective utilisation of indigenous nutrients

Step 3: Apply fertiliser to fill the deficit between crop needs and indigenous supply

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SSNM strategies should be followed in the areas facing one or more problems such as areas having low yield levels due to unbalanced use of fertilisers, areas with heavy pest infestation on the crops due to overuse of N fertiliser or inefficient use of potash fertiliser, areas with the evidence of large mining of phosphorus and potassium and areas having deficiencies of secondary elements and micronutrients in crops and soils.

Conclusion

N: P: K use ratio is widening in India, and there is an immediate need to reduce the N: P: K use ratio to improve the country's crop productivity and agricultural sustainability. Imbalanced and inadequate use of fertilisers not only decreases the factor productivity but also threatening agricultural sustainability. There is a need to optimise the nutrient application in a more balanced way to maintain crop productivity and soil health. Balanced fertilisation is only a way to tackle the problem of nutrient mining from the soil. There are various ways to achieve a balanced fertilisation strategy such as recommended fertiliser dose application, customised fertilisers, proper utilisation of all the resources that can fulfil the crop's nutrient demand through integrated nutrient management approach, soil testing, and SSNM to find out the nutrient demand. The adoption of balanced nutrient fertilisation will significantly increase crop productivity and agricultural sustainability and help in ecological sustainability.

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AGRONOMIC STRATEGIES FOR DROUGHT MITIGATION FOR RAINFED *RABI* SORGHUM

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Rainfed *rabi* sorghum is an important crop of India grown in the Deccan Plateau on area about 5.6 m ha in the states of Maharashtra (3.5 m ha), Karnataka (1.6 m ha), Telangana (0.30 m ha), and Andhra Pradesh (0.18 m ha) with a productivity of 0.85 t/ha grain and 3.4 t/ha fodder. It is largely sown on shallow Entisol and Vertisol soils during the months of September on monsoon rains and complete life cycle on residual soil moisture storage of monsoon rains and post monsoon rains that received on an average 100 mm during the months of October-December. Guhathakurta and Elijabeth, (2012) and Jain and Kumar, (2012) reported that the amount, timing and frequency of monsoon and post monsoon rains in the Deccan Plateau region is highly unpredictable and unreliable, that leads frequent drought situation in the region during the crop growing period. In majority cases *rabi* sorghum face terminal drought (Table 1) that cause 61 to 96 % loss in grain and 54 to 69 % in fodder yield (Kholova *et al.*, 2013). In addition to erratic rainfall behaviour, the unfavourable soil physical conditions of Vertisol soils preventing timely sowing and low water holding capacity of shallow Entisol soils leads moisture stress at different growth stages during cropping cycle that makes drought situation more venerable.

Table-1 Magnitude of yield losses in sorghum cultivar M-35-1 due to drought

Type of Droughts		% yield losses due to drought in comparison to zonal potential		Pattern frequency (%)	Zone potential
		Grain yield	Biomass yield		
Terminal droughts	Vegetative stress	95.8	68.6	07.0	3.1t grains ha^{-1} 8.3t biomass ha^{-1}
	Pre flowering stress	85.4	63.9	18.0	
	Post flowering stress	61.2	54.0	18.0	
Post flowering relieved stress		62.3	57.3	17.0	
Mild stress		63.2	61.4	40.0	

Source: Kholova *et al.*, (2013)

Rainfed *rabi* sorghum is the major source of food and fodder in the Deccan Plateau region, and as such, it greatly influences the economic wellbeing of the population in the region. In region, the productivity of rainfed *rabi* sorghum is far less than that the actual yield potential of available cultivars only due to drought problem. To meet the future food and fodder needs of the increasing human and animal population in the region, it is required to increase production and productivity of rainfed *rabi* sorghum.

Agronomic Strategies for Drought Mitigation

Since sorghum is drought tolerant, the 13 to 15 days moisture stress at any growth stage did not affect yield, but moisture stress more than 27 days significantly reduce yield (Eck and Musick, 1979). Data presented in Table-1 indicated that yield losses due to drought in rainfed *rabi* sorghum are highly variable, depending on magnitude and duration of moisture stress and crop growth stage at which moisture stress encountered the crop. Keeping these facts in view, we summarized the drought mitigation potential of different agronomic practices for different soils types and different type of drought situations.

Timely sowing

Sowing time is the foremost non-monetary input influencing crop growth, development and yield. Sowing at optimum time improves the productivity by providing suitable growing environment at all the growth stages. Rainfed *rabi* sorghum largely sown during the month of September on monsoon rains, and complete life cycle on residual soil moisture storage of monsoon rains and post monsoon rains that received on an average 100 mm during the months of October-December. In, Deccan Plateau region, timely sowing helps out the *rabi* sorghum by three ways. First, the timely sowing ensures good crop establishment. Second timely sowing facilitated crop for efficient utilization of rainwater received during monsoon and post monsoon periods because timing, frequency and amount of monsoon and post monsoon rains are highly unpredictable and unreliable in the region that leads frequent drought situation during the crop growing period. Third way, the flowering stage of rabi sorghum is highly sensitive to low temperature. If night temperature falls below 10^0C during flowering stage, it causes peculiar damage to fertilization process, that result partial or complete absence of seed setting (Reddy *et al.*, 2014; Mukri *et al.*, 2010). Hence, early sowing invites low night temperature problem, and late sowing invites crop establishment and moisture stress problem at later stages of crop. The different research

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findings also talk about the beneficial effect of optimum sowing time. Kalhapure and Shete, (2013) reported that *rabi* sorghum *cv*. Phule Anuradha gave highest grain (2179 kg) and fodder (4902 kg) yield ha^{-1}with sowing date 15th September in comparison to grain (1741 kg), fodder (4097 kg) and grain (942 kg), fodder (2485 kg) yield ha^{-1}with sowing dates 30th September and 15th October, respectively. Each week's delay in sowing after 12th May shortened the total growth cycle by 5·9 to 6·0 days, with 77 to 78 per cent in the vegetative phase, 7 to 8 per cent in the head development phase and 14 to 16 per cent in the grain filling phase in photosensitive sorghum cultivar.

Optimum plant population

Plant population is the second most important non-monetary input influencing crop growth, development and yield. Optimum plant population improves the productivity by providing suitable growing conditions at all the growth stages. Rainfed *rabi* sorghum largely growing on shallow Entisol and Vertisol soils during the months of September on residual soil moisture of monsoon rains. The water storage capacity of these shallow Entisol and Vertisol soils are low that results crop frequently face different type of terminal droughts depending on soil type at different growth stages of crop. Under these situations, optimum plant population act as a strategy which reduce intensity of drought stress by changing the timing of water use. The small plants planted at optimum distance in the field, will use all of the water that is in the immediate vicinity of where they are growing, but are not big enough (root system) to get to the water in the middle area when they are small. However, as they approach maturity, the plants are large enough to get to the reserve of water in the middle area. The key point here is the critical moisture demand period for sorghum development is heading. Because sorghum is sensitive to drought during flowering, the water reserve in the middle area tends to counteract the drought that commonly occurs during flowering in the Deccan Plateau region. In a close planting, where the plants are more closely distributed in the field, soil water is used as the plants grow and is depleted earlier in the season. The optimum plant population ensures that some water will still be left in the soil profile for the crop during that critical period at pollination. That extra soil moisture reserve then can result in better sorghum yields in shallow Entisol and Vertisol soils of the region. In addition to rationalizing crop water use, optimum plant population improves crop microclimate, which reduces disease and pest attack problems. The papers also talk about the beneficial effect of optimum plant population. The data of AICRPDA annual report (1981) indicated that increasing plant population from 45 (x 1000/ha) to 135 (x 1000/ha) increase mean grain yield of sorghum of three location (Bellary, Bijapur and Solapur) from 2035 to 2401 kg/ha but further increase in plant population decrease sorghum yield at all locations, it could be due to dance population consume store soil moisture at early growth stages which result crop encountered moisture stress at critical stages. Lamani *et al.,* (1997) reported that growth attributes viz., plant height, leaf area index (LAI), leaf area duration (LAD), leaf area ratio (LAR) absolute growth rate (AGR) relative growth rate (RGR) net assimilation rate (NAR) showed a decreasing trend with the increased plant density. Increased population affected all the growth attributes severely due to mutual shading and competition for water and nutrition, which is a result of decreased LAD and LAR.

Fig. 1 Farmers field photo, which indicates beneficial effect of optimum plant population.

Selection of cultivars

Rainfed *rabi* sorghum faced different degree of moisture stress at various growth stages every year, due to erratic rainfall behaviour and low water storage capacity of eroded shallow Entisol and Vertisol soils. Once in three-year, crop faces severe moisture stress, which leads total crop failure. Beside moisture stress unfavourable soil physical conditions preventing timely sowing that leads low night temperature, terminal heat stress, diseases and past incidence early crop establishment problems. Under these environments' performance of *rabi* sorghum cultivars controlled by traits such as tolerance to drought, matching with potential sowing dates, 110 to 130 days maturity duration, registrant to low night temperature stress, matching with different soil conditions, high seedling vigor for early crop establishment and registrant to disease and pests.

Among these traits, selection of cultivars based on soil condition is one of the most viable traits for the Deccan Plateau region. Because sorghum growing area of region characterized by different soil types ranging from shallow Entisol soils to medium to deep Vertisol soils. Under these situations, depth of soils determines the magnitude of yield losses due to moisture stress. In shallow soils shorter-season cultivars such as Selection 3 (Phule Anuradha) performs better than medium to longer-season cultivars such as M 35-1 (Phule Suchitra). It could be due to the shorter-season cultivars completed their flowering period before terminal moisture stress started in shallow soils and shorter-season cultivars consume less water than a medium to longer-season cultivars at all stages of growth.

Planting depth

In Deccan Plateau region rainfed *rabi* sorghum growing in different soil conditions ranging from shallow Entisol soils to deep Vertisol soils. Every soil condition has their own merits and demerits, such as Entisol soil shaving better germination and better crop establishment due to light texture, which facilitated timely tillage and sowing operations. Timely tillage and sowing operations increased the duration of moisture range which is suitable for seed germination and seedling emergence. But on the other side, Entisol soils having low clay content that reduces water storage capacity of soil, which leads moisture stress in crops earlier than Vertisol soils. The Vertisol soils having good water holding capacity due to high clay content and most suitable for dryland farming but germination and early crop establishment was poor in these soils due to heavy texture. The physical properties of Vertisol soils are greatly influenced by soil moisture content. Usually, these soils are too sticky and unworkable when wet and very hard when dry. These physical conditions of Vertisol soils narrow down the soil moisture range which is suitable for tillage and sowing operations. The delayed sowing operations affects moisture range which is suitable for seed germination and seedling emergence that resulted increased timing between sowing and seedling emergence, affects early season plant uniformity and plant stand.

Sorghum is a small seed, and it should be planted shallow for better crop establishment, but above-mentioned unfavourable soil physical conditions make planting

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depth/seed placement depth a critical factor for rainfed *rabi* sorghum. The shallower or deeper planting depths can affect the time between planting and emergence, affecting early-season plant uniformity. In Deccan Plateau region, planting/seed placement depthof rainfed *rabi* sorghum was determined by soil type and moisture availability. In medium to deep Vertisol soils, the planting depth should not be more than 2-3cm in normal moisture conditions, while in shallow Entisol soils, the planting depth should be up to 4-5cm. In irrigated conditions a planting depth of 2-3cm resulted better than shallower (<2cm) or deeper (>3cm) planting. Under dry conditions the seed should be planted deeper 4-5 cm in both soil types, but no more than 5 cm in any condition.

Planting direction

Solar irradiance is the primary source of energy that is converted into soil, sensible, and latent heat fluxes in the soil-plant-atmosphere continuum. The row orientation of agricultural crops relative to the sun's zenith angle determines the amount of solar irradiance reaching the plant and soil surfaces and its partitioning via absorption and reflection from soil and vegetation. Row orientation also affects soil heat flux and evaporation. Since soil evaporation may be considered as a non-productive water loss, minimizing soil evaporation improves water use efficiency. In Deccan Plateau region yield of rainfed *rabi* sorghum is primarily water-limited. In such conditions, unproductive water loss in the form of soil evaporation may also become a critical factor for crop yield. Steiner (1986) reported that water use efficiency, harvest index, grain yield and stover yield of sorghum was higher in the north-south row orientated crop in comparison to east-west row orientated crop with less evapotranspiration.

Nutrient Management

Low soil fertility status and submarginal availability of soil moisture are the major biophysical constraints of eroded shallow Entisol and Vertisol soils. Availability soil moisture in submarginal levels limits the effectiveness of fertilizers and increases the economic risk of fertilizer use. It is generally reported that adequately fertilized soils promote rapid root growth, leaf area expansion and more rapid ground cover, thus reducing evaporation. Better rooting and leaf area expansion enabled the plants to extract water from deeper soil profiles thus reducing moisture stress that resulting in increased crop productivity, nutrient use efficiency and water use efficiency. Singh and Das, (1995) reported that increased soil-moisture storage and its availability to crop plants at critical growth stages improve the fertilizers use efficiency. In drought prone areas of Deccan Plateau, higher yield of *rabi* sorghum was obtained in a deep soil having more stored water compared to a shallow soil, with a response up to 75 kg N ha^{-1} in the deep soil and only up to 25 kg N ha^{-1} in the shallow soil. Prasad, *et al.*, (2009) reported that balanced fertilization improves grain yield and agronomic nitrogen use efficiency of sorghum in rainfed areas. The agronomic N use efficiency of applied N was increased by applying P and K fertilizers, from 5.3 (N alone) to 12.0 kg sorghum grain kg^{-1} N and grain yield increased from 1.48t ha^{-1}with alone N to 1.75 t ha^{-1}with NPK in comparison to 1.27 t ha^{-1}with no fertilizers application. The standard fertilizer recommendation to rainfed crops in semiarid regions in India is to drill or place the basal application 5 to 10 cm deep in the root zone. In the rainy season, a portion of the N dose and all P and K are applied basally. During the dry season, when little or no rainfall is expected, full amounts of nutrients for the entire crop season are recommended to be applied basally. Venkateswarlu, (1987) found that grain yield can vary from 340 to 1,500 kg grain ha^{-1}by adopting the recommended fertilizer placement method in rainfed areas.

Timely weeding

In dryland areas, timely and effective weeding is the foremost agronomic practices that could bring immediate positive effects on crop growth and yield. Out of total yield losses caused by pests (insects, diseases and weeds) in crops, weeds alone account for one-third of the yield losses. The problem becomes more severe in rainfed areas, where soil moisture is the major yield limiting factor. Sorghum is particularly vulnerable to damage by parasitic weeds like *Striga lutea*, *S. asiatica* and *S. hermonthica*, two hands weeding are normally required, the first can be carried at thinning and another one at 35 to 45 day after sowing (Reddy *et al.*, 1976)

Conclusion

From the above, it could be inferences that:

1. In Deccan Plateau region yield of rainfed *rabi* sorghum is primarily water-limited.
2. Sowing time is the foremost critical factor which avoids and reduces moisture stress intensity through manipulating crop growing conditions at all crop growth sages.

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3. Plant population is the second most important critical factor which reduces moisture stress intensity through rationalizing, timing of water use of crop.
4. Selection of cultivars based on soil condition improves crop productivity through avoiding and reducing moisture stress intensity by utilizing water in efficient way.
5. Unfavorable soil physical conditions and moisture availability at sub marginal level makes planting depth a critical factor for rainfed *rabi* sorghum production in region.
6. Row orientation influence solar irradiance, soil heat flux and soil evaporation which affects water use efficiency.
7. Optimum fertilization enabled the crop plant to extract soil moisture from deeper soil profiles, thus reducing moisture stress and resulting in increased crop productivity
8. Timely weeding reduces water losses from soil profile that reducing moisture stress and resulting increased crop productivity

In conclusion, since all above revealed, agronomic strategies reduce moisture stress. But based on their drought mitigation potential, we ranked these practices as: - sowing time ≥ plant population> selection of cultivars based on soil conditions ≥ nutrient management>timely weeding≥planting depth> planting direction.

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FISH VACCINES AND THEIR ROLE IN DISEASE MANAGEMENT

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Vaccination is an elementary, effective and preventive method of protecting fish from diseases. Vaccines are antigens derived from pathogenic species that have been made non-pathogenic by different methods in order to activate the immune system and improve susceptibility to disease from subsequent infection by a pathogen. Vaccination is the paramount method to increase survival rate and efficiency in aquaculture when used in combination with several factors like a balanced diet, good farming and husbandry practices, proper health monitoring and management, which are necessary to guarantee the highest possible survival rate. In 1976, the first aquaculture vaccine, a yersiniosis vaccine for salmonid fish, was approved in the United States (Plumb 1999). The first report on fish vaccination was given by David C. B. Duff, and he is regarded as "Father of fish vaccination".

Ideal Characteristics of Fish Vaccines

- Cheap and safe
- Easily produced
- Stable
- Sustained immunity and protection
- Easy mass application
- Efficacious for a broad number of species
- Will not interfere with diagnosis
- Easily licensed

Importance of Vaccination

- Use as prophylaxis against the disease before the occurrence of disease.
- Used to prevent a specific disease outbreak from occurring
- Efficient
- No side issues, no accumulation of toxic residue
- Vaccines are not the same as antibiotics; pathogen will not develop resistance.

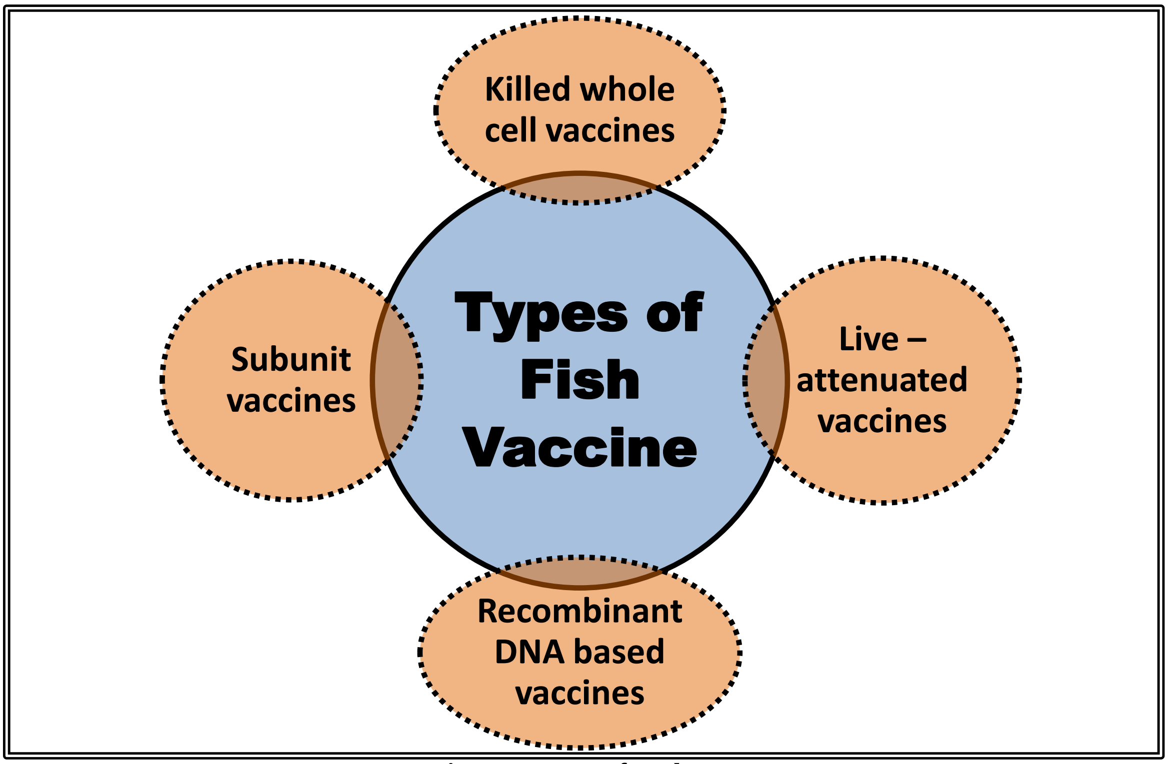

Fig.1: Types of Fish Vaccine

Vaccines aren't the same as antibiotics, and they won't be able to avoid a disease outbreak once it's started. Vaccines are used to prevent the outbreak of a specific disease and are not a remedy. Its efficiency exists for a longer duration with one or more treatments. Vaccination seems to be a more important part of aquaculture because it is a cost-effective way to manage a variety of diseases that pose a threat. Its efficiency exists for a longer duration with one or more treatments. There are different types of fish vaccines produced in aquaculture to induce an immune response in an organism. (Fig.1)

1) **Killed whole cell vaccines:** The vaccines are prepared from the suspension of heat or chemical – killed pathogens. All the killed vaccines are formalin inactivated whole cell vaccines administered with or without adjuvant. They are highly immune-

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protective and are cheap to produce. The disadvantages are that they have a little residual effect and weaker stimulation of cell mediated response (Tlaxca *et al*., 2015).

2) **Live – attenuated vaccines:** Suspension of attenuated live pathogens that are capable of replicating inside the host. These are live micro-organisms that have been cultivated under conditions that disable their virulent properties and induce protective immune response but are unable to cause disease. They are capable to induce both humoral and cell mediated immune response. The drawback is facing problem in their storage and shelf-life.**(Roy, 2011)**
3) **Recombinant DNA based vaccines:** They are also called new generation vaccines. Formation of new combinations of genetic material by insertion of nucleic acid molecules produced outside the cell via a vector system.
    - **Recombinant protein vaccines:** Identification of the immunogenic subunit or protein from the pathogens of interest and verification of its immunogenicity *in vitro and in vivo.* The vector system usually used to express recombinant proteins are viruses or bacterial plasmids. Both prokaryotes and eukaryotes expression system have been used.
    - **Peptide vaccine:** Peptide vaccines comprised of synthetic peptides that are able to induce a protective immune response when administrated into the host. For the production of peptide vaccines, it is necessary to immunogenic identity regions or 'epitopes' on the antigens protein.
    - **DNA vaccines:** DNA vaccines consist of a suspension of bacterial plasmids carrying the gene coding for the immunogenic protein under the control of the eukaryotic promoter.
4) **Subunit vaccines:** Subunit vaccines contain a portion of the infectious agent, which is essential for stimulation of protective immunity. Subunit fish vaccines are commercially available. These vaccines are safe and inexpensive, but there may be inadequate cellular immunity **(Seder and Hill, 2000)**.

Adjuvants are a pharmacological or immunological agent that is co-injected with antigen in order to help stimulate and enhance the adaptive immune system into producing antibodies against the antigen.

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Vaccination Methods

1. **Injection Vaccination:** Most common method of vaccine delivery by intraperitoneal or intramuscular injections in fish. It is an effective way of provoking an antibody response. The major drawbacks are it is time consuming, labour intensive and consequently expensive to administer the vaccine to a large number of fish. Significant handling stress and due to small size fry cannot be vaccinated by means of injection (Fig. 2).

Fig. 2: Injection vaccination

2. **Immersion Vaccination:** Different types of immersion techniques are used as a commercial process. Like bath method, dip method and spray method. It is a hyperosmotic immersion technique were prior to immersion in antigen solution, fish are dipped for a short time in a hyperosmotic salt solution, which enhances the intake of antigens. Suitable for mass vaccination of all sizes of fish, lower labour costs. Major disadvantages are a large amount of vaccine required and lower level of protection and duration of immunity (Fig. 3).

Fig. 3: Immersion vaccination

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3. **Oral Vaccination:** It is one of the easiest methods of mass vaccination of any size of fishes. Vaccine mixed with feed, different new approaches with microencapsulation, bio encapsulation or other ways of incorporation of antigens is promising. The main limitations of this method are large quantities of antigen required to obtain effective immunity, lower efficacy and protection generally weak and of short duration (Fig.4). (Komar et al., 2004)

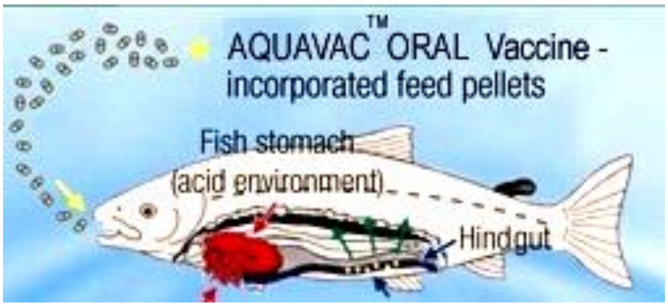

Fig. 4: Oral vaccination

Factors Affecting Response to Vaccine

- Species (age and size)
- Effects of preexisting disease
- Method of administration like for immersion vaccines the concentration, exposure time and use of any hyperosmotic infiltration procedure affect the response.
- For oral vaccines the method of incorporation in feed
- Farming technology (Handling, mechanisation)
- Environment (temperature, salinity)
- Stress factors, nutrition and cost benefit

Successful Vaccination

The major causative agents of infectious diseases in finfish aquaculture include fungi 3.1%, parasites 19.4%, viruses 22.6%, and bacteria 54.9%. There are several successful vaccines produced for bacterial diseases. In spite of the amount of research performed, both in commercial companies and in academic organizations, few viral vaccines are licensed. No parasite vaccines are commercially available.

In general, fish possess both humoral and cell-mediated defence mechanisms against many parasites, and there are many reports on immunity / increased resistance among fish surviving natural parasitic infection. Cultivation of parasites for potential killed or live vaccine is even more expensive than virus cultivation.

Optimal effects of vaccines

Proper fish health management, including good hygiene and minimal stress, is important in the prophylaxis of infectious diseases and is also required for vaccines to work optimally. Using efficient vaccines and administering them correctly is not the only factors affecting the effects of vaccines. Proper fish management practices will help vaccines perform at their best. Optimal conditions and adequate nutrition are very important, and one must also strive to expose the fish to as little stress as possible. The efficiency of a vaccine largely depends on the condition of the immune system, and exposing fish to factors that might harm their immune system is therefore highly unadvisable.

Following is the list of some successful vaccines used in aquaculture-

Table1: List of Fish Vaccines Developed

Disease	Vaccine	Fish Species	Route of Administration
	1. Bacterial vaccines		
Furunculosis	*Aeromonas salmonicida* Bacterins	Atlantic salmon	**I, Im, O**
Vibriosis	*Vibrio salmonicida* Bacterin	Salmonids	**Ip**
Enteric septicaemia	*Edwardsiella ictaluri* Bacterin	Channel Catfish	**Im, O, I**
Columnaris	No commercial vaccines	Ictalurids, eels, Salmonids, cyprinids and ornamental fish like goldfish	**-**
Yersiniosis	*Yersinia ruckeri* Bacterin	Rainbow trout, Atlantic salmon	**I**
Bacterial kidney disease	*Renibacterium salmoninarum* bacterin	Salmonids	**I**
Mycobacteriosis	-	Freshwater and saltwater fishes	**No vaccines are available**
Dropsy	Biofilm and free-cell vaccines of *Aeromonas hydrophila*	IMC's	**I**
Streptococcosis	*Streptococcus agalactiae* (group B) vaccine	Tilapia	**I**

2. Viral Vaccines			
Infectious pancreatic necrosis (IPN)	Inactivated vaccines, DNA vaccine	Atlantic salmon	**I**
Spring viraemia of carp	Spring viraemia of carp virus	Common carp	**I**
Pancreas disease	Salmon pancreas disease vaccine	Salmonids	**I**
Koi herpes virus	Koi herpes virus (KHV)	Koi carp	**I**
3. Fish Vaccines against Parasites- No vaccines are available			

*Where, I-Injection, O-Oral route, Im-Immersion and Ip- Intra peritoneal

Conclusion

Vaccines are currently available for a range of economically significant bacterial and viral diseases. Vaccines for parasitic and fungal diseases, on the other hand, have yet to be generated. Major limitations in fish vaccine developments are less understanding of fish immunology, many vaccines unlicensed, not cost effective (expensive) and stressful on administration. Fish vaccination is still quite an infant stage, but innovative advances can be made. Vaccines are tools that can be used in conjunction with good health management and biosecurity plans to give aquaculture producers the most benefit. To be sustainable, aquaculture requires efficient and safe vaccines that can be converted into licensed products.

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SUSTAINABLE AND CLIMATE SMART AGRICULTURE: CHALLENGES AND OPPORTUNITIES IN INDIAN PERSPECTIVE

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Supplying sufficient nutritive food for ever growing population has always been remained the most imperious challenge for the developing nations. During the twentieth century the developing nations tried to fulfil this challenge with increased agricultural production using external inputs i.e. synthetic fertilizers and other agrochemicals. The green revolution technology substantially increased the agricultural production with the help of modern agricultural practices at the cost of natural resources. Thus, a considerable decline in natural resources like degradation of soil fertility and environmental quality was observed. These adverse effects led to go with the approach of traditional agriculture with minimize use of external inputs. This approach has been defined as sustainable agriculture in recent time. The sustainable agriculture is the admixture of modern agricultural practices along with traditionally adapted healthy practices. Therefore, sustainable agricultureis not only resource conservative but resilient to current climate change scenario.

Being a sole food provider to the animal kingdom of the planet, agriculture employs a key role in economic development of agrarian economy like India. Agriculture based industries are the largest industry across the globe as it covers~ 40% of total available land. When it comes to the average per capita energy requirement ~78% of total per capita energy requirement is fulfilled by crop-based products, while ~20% energy is contributed by other products i.e. meat, milk and eggs (Singh *et al.*, 2019). Thus, meeting out the food demand of ever growing human and animal population from decreasing land resource under agriculture is the major challenge in present scenario which can be only attained by increasing the agricultural production. Besides the non-agricultural use of agricultural land resources, changes in global climate is also a major concern for sustainable agricultural production. As per the reports of International Panel on Climate Change (INECC, 2010) enormous increase in greenhouse gases emission (carbon dioxide, methane, nitrus oxide and chlorofluoro carbons) from both agriculture and non-agricultural sectors have led to increase in global temperature by 0.6 to 0.8 ºC and changes in rainfall patterns around the world. These adverse changes in global climate has directly or indirectly affected the sustainability of agricultural production across the globe. In India, agriculture and its allied sectors not only contribute to ~ 17% of total gross domestic product (GDP) but it also provides ~2/3 employment of total employment in India (Directorate of Economics and Statistics, 2019). The livelihood of rural population of India which is about 58% of total population directly depends on agriculture. Therefore, potential growth of Indian Agricultural sector is directly associated withpoverty alleviation and employment generation in developing economies like India. The dimension of Indian Agriculture can be illustrated from figure 1.

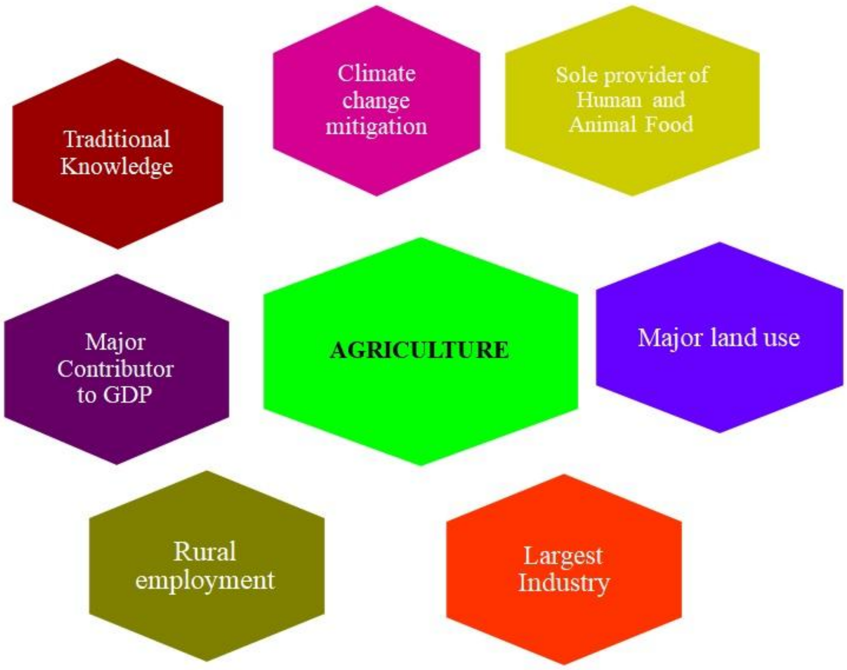

Fig. 1. Role of Agriculture in present scenario (Source: Singh et al., 2019)

Further, the agriculture industry is facing various challenges from different non-agricultural sectors and changing climate, therefore, the agricultural industry has adopted several measures to cope up with these challenges. The challenges to agricultural sector can be depicted from figure 2.

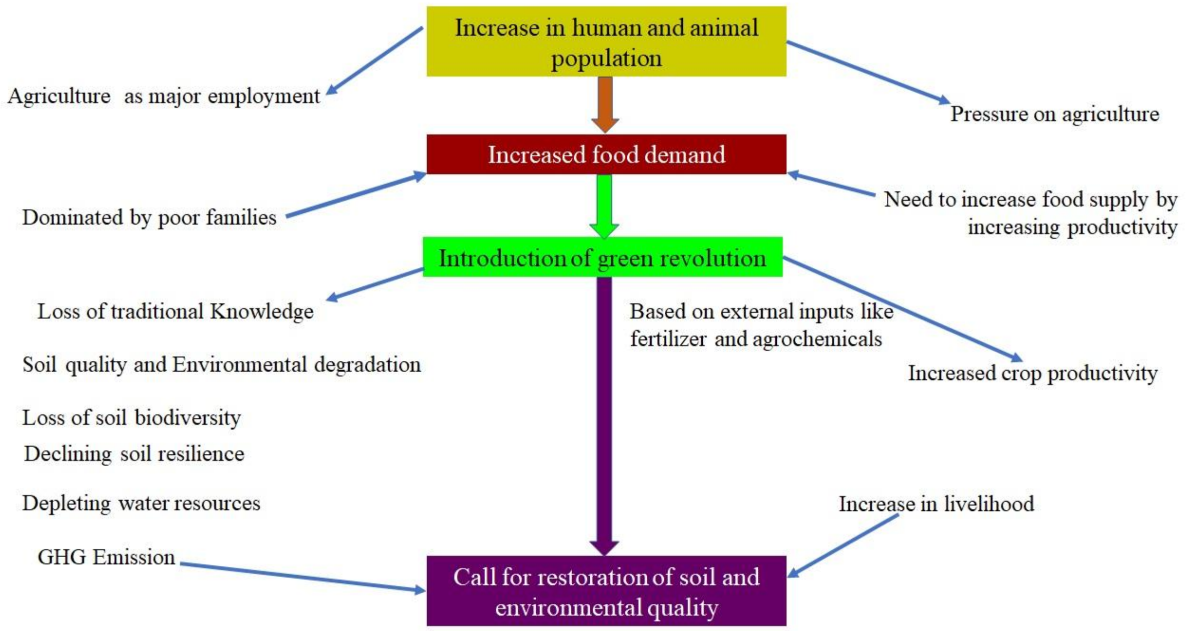

Fig. 2. Challenges and opportunities in agriculture sector (Source: Singh et al., 2019)

With the current decadal growth rate of 18%, the Indian population will be 1.5 billion by 2050 which has created enormous pressure on natural resources in India as India has only 2.2% of global geographical area. Only 46% area out of the total 32.8 Mha area is under cultivation in India. The green revolution was introduced in Indian agriculture in the later half of 20th century with the three basic principles i.e. meeting out the food demand of people, with limited natural resources and increase in crop production with the help of external inputs (Singh et al., 2017). This green revolution increased the agricultural production in India as much as 4 to 5 folds in comparison to 1950-51 and helped India to become self-sufficient in food production. Though, green revolution substantially increased the agricultural production but the adverse impacts of green revolution technologies in the later 20th century has led towards the critical scrutinization of these technologies. Thus, these adverse impacts on soil and environmental sustainability created a need of sustainable agricultural production system to overcome those challenges of Indian Agriculture under changing climate scenario.

Challenges for Indian Agriculture

Though the green revolution technology enormously increased the agricultural production in India but it also enhanced the use of chemical fertilizers and pesticides to the tone of seven and 375 folds. This uncontrolled consumption of synthetic products has resulted in some devastating effects on Indian agriculture. Therefore, the internal regulation

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in the biological interactions, agro-ecosystem functioning and over all environmental sustainability has been subdued by this external input-driven approach. Excessive application of synthetic agro-chemicals has led increased soil, water and environmental pollution. In a large scenario, the green revolution has led the socio-economic disparity among the Indian farming community as its favoured the large landholding farmers and agro-based industries but has negative impacts on small and marginal farming community besides the adverse impacts on water resources, environment and soil fertility (Kumari et al., 2019). Therefore, Indian agriculture is facing the following major challenges in post green revolution era:

1. Food security
2. Depletion of water resources
3. Deterioration of soil quality
4. Nutrient availability
5. Socio-economic disparity among farming community

Food Security

Food security can be defined as reliable access to sufficient quantity of nutritious food. Though, the enormous food production post green revolution has declined the undernourished population from 18.6% in 1990-92 to as low as 10.9% in 2014-16. But still many people across the country facing the food and nutritional insecurity. Thus, sustainable achievement of food security is the major economic, political, sociological and scientific challenge in the 21st century. As per the global estimates the average per capita energy requirement is 2780 kcal day^{-1}, but in the developing and under developed economies the per capita energy availability is less than 2200 kcal day^{-1}. India has performed well in achieving the goal of food security in last three decades but still the country has to achieve many more in the area of sustainable food production.

Depletion of water resources

Water is the major factor in agricultural production. The Indian agriculture is predominantly dependent on monsoon which results in uncertainity in water availability for agricultural production. Thus, canal and well irrigation systems have played a crucial role in agricultural production in Indian context. Development in canal and well irrigation systems have increased the irrigated cropped area to the tone of twofold in last 50 years. But this development has led the over exploitation of ground and surface water resources in agricultural system and as per the reports of Ehrlich and Harte (2015) ~30% of the total freshwater withdraw from resources is used for rice cultivation across the globe while in Asian continent >45% of freshwater is utilized by flood irrigated rice crop. Therefore, the resource-intensive agriculture has impeded the continuous availability of freshwater in present changing climate scenario. The crop yield is severely influenced by water scarcity compared with other challenges and continuous exploitation of water resources will lead to rising food prices, food shortage and higher food imports by the third world countries (Arulbalachandran et al., 2017). Injudicious use of water resources has also increased the waterlogging and intensified the process of soil salinization. Therefore, proper irrigation water management, judicious use of water resources should give proper attention by the policy makers.

Deterioration of Soil Quality

Intensification of agricultural practices has first and foremost consequences on soil. Soil organic carbon (SOC) is considered as an important soil quality indicator as it directly or indirectly controls soil structure maintenance, nutrient cycling, pesticide and water retention. Enormous use of agro-chemicals in intensive farming has alarmingly declined the soil organic matter (SOM) content which is the main cause of deteriorated soil quality (Sankar Ganesh et al., 2017). Alteration in SOM quantity in soil has also led the reduced microbial diversity of soil which further has a negative impact on soil quality. As per the reports of Pal *et al*. (2015) the level of SOC Indian soils varied from 20 to 25 Gt carbon in the top one-meter soil depth, thus most of the Indian cultivable soils contains 4-8 g kg^{-1} SOC. As per an estimate the food product of 40% human population across the globe is derived by nitrogen based chemical fertilizers and therefore, the nitrogen fertilizer demands are increasing at the rate 1.7% per year (FAO, 2011). If we talk about the India and China, they alone consume the ~ 49% of total fertilizer consumption in Asia. Injudicious use of chemical fertilizers and subsequent decrease in organic manures application has led to acidification of tropical Indian soils which resulted in deterioration of soil quality and productivity. More than 60% of cultivable land has been degraded by indiscriminate use of chemical fertilizers, excess nutrient mining and multi nutrient deficiencies. Therefore, the sole application of chemical fertilizers has led reduction in crop productivity of tropical Indian soils in two ways i.e. decreased soil fertility, deteriorated soil biodiversity and nutrient use efficiency and hinder crop productivity.

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Nutrient Availability

Seventeen different nutrient elements have been identified as essential plant nutrients for proper growth and development of crop plants (Sathya et al., 2016). These elements have been categorized as macro and micro nutrients based on their requirements to the crop plants. The macronutrients are further divided into primary and secondary nutrients based on their rate of consumption by the plants as the primary nutrients are consumed rapidly by the plants compared with the secondary nutrients. Thus, the primary nutrients are supplied through the straight fertilizers, while the other nutrients are available through organic manures, biological nitrogen fixation and plant residues (Sankar Ganesh et al., 2017). Tough the micronutrients are required in less quantity in comparison to macronutrients, but they are essential part of carbon, protein and lipid metabolism enzymes. Injudicious use of single nutrient based chemical fertilizers i.e. nitrogenous, phosphatic and potassic fertilizers accompanied by soil erosion and surface runoff have resulted in deficiency of secondary and micronutrients in most of the Indian soils. This multi-nutrient deficiency has led the reduction in crop productivity due to nutrient deficiency induced metabolic disturbances in the crop plants. Mobility of micronutrients is governed by several factors i.e. organic matter, pH, chemical factions of these micronutrients and their concentration and soil-plant-microbes interaction (Shukla et al., 2015). Therefore, for sustainable crop production, judicious and integrated use of synthetic fertilizers and manure, use of efficient crop varieties, improved agronomic management practices and proper soil-plant-microbes interaction is highly necessitated.

Socio-Economic Disparity among Farming Community

The Indian agriculture is highly dominated by the small and marginal farmers which accounts 88% of total farming community India. This small and marginal farming category is mostly dominated by the Schedule tribe and Schedule caste categories (Nath et al., 2018). Other than this, the small and marginal land holders cultivate on 72Mha land and contribute about 56-60% of India’s total food requirement but their land holdings among the most climatically and ecologically vulnerable lands. Thus, the changing climate scenario followed by environmental degradation, hunger, poverty and land degradation has great impact on these small and marginal farmers. Shifting of Indian farmers towards mono crop and cash crop cultivation has increase the threat to long-term sustainability of Indian agriculture. In a whole, the green revolution technology alone cannot achieve the challenges of soil quality deterioration, food security and farmers' socio-economic status because of many undesirable impacts of this technology. Therefore, there is urgent need of such technologies which is ecologically sound coupled with low external inputs and traditional knowledge to meet the changing climate scenario (Srivastava *et al.*, 2016).

Sustainable Agriculture

Research studies across different parts of the India as well as the globe have proved the adverse impacts of green revolution on soil microbial biodiversity. Other than that stagnation in crop yields have been noticed in the Indo-Gangatic plains where, the green revolution technology flourished. Enormous and injudicious use of agro-chemicals has led the emission of green-house gasses from agricultural sector which resulted in global warming and climate change. Therefore, the focus of agriculture research has been shifted towards holistic natural resource management for long-term crop productivity to achieve the food security (Sathya et al., 2016). Maintenance of soil quality and soil health is an essential component for long-term crop productivity which can be achieved with the use of efficient resource conservation technologies i.e. integrated use of organic manures along with synthetic fertilizers, biofertilizers and inclusion of organic manures in the production systems. Thus, sustainable agriculture is the only way to meet the food demand of growing global population along with long-term protection of crop productivity and improved soil health (Barea 2015). As per the standard definition of sustainable agriculture as outlined by Corwin et al. (1999) "sustainable agriculture concept is predicted on a delicate balance of maximum crop productivity and economic stability, while minimizing the utilization of finite natural resources and detrimental environmental impacts." As per Tilman et al. (2002) "sustainable agriculture is the practices that meet current and future societal needs for food and fibre, for ecosystem services, and for healthy lives, and that do so by maximizing the net benefit to society when all costs and benefits of the practices are considered." The need and basis of sustainable agriculture can be understood from figure 3.

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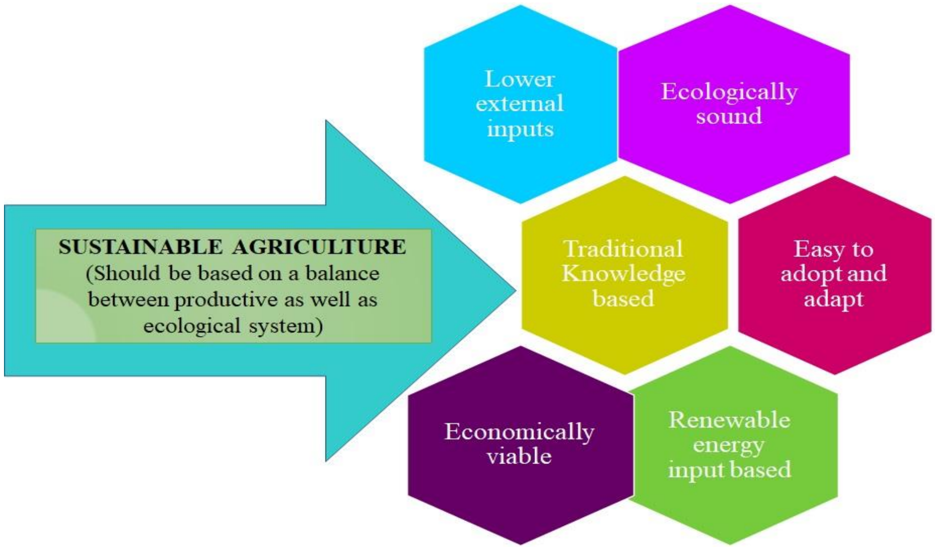
Fig. 3. Need and basis of the sustainable agriculture (Source: Singh et al., 2019)



The sustainable agriculture is the integration of traditional as well as modern scientific knowledge which is not only economically viable, easy to adopt but also ecologically sound practice which emphasize on the use of renewable energy input resources. It integrates the progressive coordination among the different stakeholders by adopting temporal adaptation and ecologically sound traditional knowledge. Environmental, social and economic sustainability are the three main pillars of sustainable agriculture. All these three pillars are adjunct in three P's framework i.e. planet-people-profit. Thus, most of the researchers have elaborated the primary goals of sustainable agriculture as (1) promotion of prosperous social livelihood of farming community, (2) minimal damage to environmental resources and promotion of environmental stewardship through improved soil quality and decreased dependency on non-renewable resources and (3) Provision of more profitable farm incomes. Sustainable agriculture integrates comprehensive range of soils, pest and nutrients management technologies i.e. crop residues, dung, biological nitrogen fixation, crop rotations, mixed cropping etc. (Mtengeti et al., 2015).These sustainable agriculture measures are beneficial for biological diversity, improved soil quality and nutrient pools, ecosystem restoration and climate resilience by decreasing the soil degradation on one hand and increasing socio-economic status of farmers on the other hand. However, subsidized rate of synthetic fertilizers and poor availability of organic nutrient sources is major constraint for shifting towards sustainable agroecosystem. Thus integrated nutrient management which combines the use of organic and inorganic inputs are being advocated in sustainable agriculture for augmenting the soil quality and nutrient pools. In a nutshell, sustainable agriculture is basically depending on the facts of more output with less environmental resources. Recently many technologies i.e. organic farming, conservation agriculture, integrated nutrient management precision agriculture, biofertilizers etc. have been emerged for sustainability of agricultural system (Srivastava et al., 2016).

Conclusion

Though the green revolution has successfully delivered the role of food provider to the large population at a great extent. But the excess use of external inputs like synthetic fertilizers and other agrochemicals have led to degradation of natural resources and environment. In such changing climate scenario sustainable agriculture has been emerged as a suitable alternative not only to maintain the long-term crop productivity and soil health but also helps in reduction of greenhouse gas emission from the agriculture and allied sectors. Sustainable agriculture performs in a way to meet current and future societal needs for food and fibre, for ecosystem services, and for healthy lives, and that do so by maximizing the net benefit to society.

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ECOTOURISM: THE NATURAL VIEW

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Tourism involves travelling to areas of natural or ecological interest for the purpose of observing wildlife and learning about the environment. This is a form of tourism as well as tourism development. It encourages going back to natural products in every aspect of life and helps in preserving nature. It is also the key to sustainable ecological development. The word ecotourism has been derived from two words, 'Ecosystem' and 'Tourism'. It entails not only travelling to such ecosystems but also helping to conserve them.

"Ecotourism that involves travelling to relatively undisturbed natural areas with specified object of studying, admiring and/or enjoying the scenery and its wild plants and animals as well as any existing cultural aspects found in these areas. Tourism which contains a visit to an ecosystem is ecotourism."

Ecotourism is now defined as "responsible travel to natural areas that conserves the environment, sustains the well-being of the local people and involves interpretation and education."

Orams (1995) argues that the majority of ecotourism definitions lie between the passive position and the active position towards the high responsibility pole on the continuum.

Ecotourism has also been defined based on three criteria (Wall, 1994) the characteristics of the destinations, the motivations of its participants, and the organisational characteristics of the ecotourism trip.

Principles of Ecotourism

1. Nature-based forms of tourism with the motivation to appreciate nature as well as culture in natural areas.

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2. Educational interest to understand the ecosystem.
3. Often specialized and small group tours.
4. Minimizes negative impacts.
5. Supports natural areas by creating economic benefits for host communities (including employment opportunities) and increasing awareness.

Characteristics of Ecotourism

- Involves travel to natural destinations
- Builds environmental awareness
- Provides direct financial benefits for conservation
- Provides financial benefits and empowerment for local people
- Respects local culture
- Supports human rights and democratic movement

Components of Ecotourism

- Contributes to conservation of biodiversity.
- Sustains the well-being of local people.
- Includes an interpretation/ learning experience.
- Involves responsible action on part of tourists and the tourism industry.
- Requires lowest possible consumption of non-renewable resources.

Ecotourism resources

The geographical diversity of India is a wealth of ecosystem, which are well protected and preserved. The ecosystem has become the major resource for tourism in India. They are as follow:-

1. Biosphere reserves
2. Mangroves
3. Coral Reefs
4. Deserts
5. Mountains and Forests
6. Flora and Fauna
7. Caves

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8. Seas, Lakes and Rivers

The key players in the ecotourism

- The key players in the ecotourism business are governments at levels, the local authorities, developers and the operators, the visitors, and the local community.
- Non-governmental organizations and scientific and research institutions also play a key role in the development of ecotourism.
- Some organizations are the Asia Pacific Ecotourism Society, Discovery Mice, World Tourism Organization, The International Ecotourism Society (TIES), and Eco India etc.

Common ecotourism activities

- Wildlife photography
- Bird watching
- Mountain climbing
- Hiking
- Nature photography
- Swimming in natural water

Ecotourism in India

India is bestowed with varied geography and natural destination spots that offer the eco-tourism hub. The concept of ecotourism has been already introduced in India, and some planned approaches have been taken up for the establishment. The government has also taken initiatives for the promotion of ecotourism in India.

Thenmala in Kerala is the first planned ecotourism destination in India. There are several ways to enjoy the beauty of the country and its nature in the most pristine way. Some places suitable for ecotourism in India are the Himalayan regions, North-Eastern India, Kerala, Andaman & Nicobar Island, Lakshadweep Islands, etc.

Conclusion

Ecotourism is an important economic activity in natural areas. It promotes sustainable use of natural resources and reduces the threat to biodiversity, and is economically profitable.

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So let us dedicate ourselves to this wonderful practice and hope it can change our world. It is really useful in conserving our biodiversity as well. According to Goodwin (1996), managers of protected areas could turn nature tourism into ecotourism, based on the motivation of their consumers, in other words, at the point of consumption or based on a sound management strategy both in terms of numbers and activities.

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BEEKEEPING (APICULTURE) AND IT'S ECONOMIC IMPORTANCE

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With proper training and advice, any business in agriculture (crop cultivation, animal husbandry, fish farming) is sure to make good profits. In that way, we will see about beekeeping for those who want to be self-employed or part-time farming. It is said that beekeeping makes agriculture prosperous and profitable. Like a beehive for the home, a lifeline for the family. In addition, bees are revered by agronomists as the angels who support ploughing because pollination improves pollination, fertility, fruit production, fruit quality, seed production, seed quality, and yield. Beekeeping is an important component of integrated farming. Its unique feature is that it does not require separate accommodation for beekeeping. Ingredients such as honey, pollen, beeswax, and royal jelly available from beekeeping lead to additional income and rural employment.

Species of bees

- There are four species of bees found in India.
- They are the giant rock bee called *Apis dorseta*, the small bees called *Apis florea*, the domesticated bees called *Apis indica*, and the small mosquito bees called *Melipona indecisa*.
- There are three types of bees: **Queen** bee, **work** bee and **male** bee. Over **90%** of them are found by **working bees**, one queen bee and a few hundred male bees.
- Usually, 20000 - 30000 bees are found in a bee family.

Lifespan of bees

The queen bee: The queen bee can live up to about two years. This is because bees provide and maintain a kind of protein-rich food called royal jelly at work.

This Royal Jelly Queen bee can live for 2-3 years and lay about 1000 eggs a day continuously.

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Workers Bees: Its lifespan is 2-3 months.

By this work, the bees themselves do all sorts of work precisely, from collecting nectar to turning it into honey and maintaining the queen and the hive.

Male bees: Their lifespan is 6 - 8 weeks. Its main function is to mate with the queen bee and fertilize the queen bee.

Rearing methods

Beekeeping is carried out in two ways.

1) Stable beekeeping

2) Transplantation beekeeping

1) **Stable beekeeping**

Stable beekeeping is the practice of keeping hives in one place on agricultural lands. This time the integrated farm is ideal for beekeeping. This is because of the variety of crops (trees, plants, vines) that provide food for the bees throughout the year. So there is no need to relocate beehives. This method can be used for up to 10-15 beehives per acre.

2) **Transplantation beekeeping**

- In this method, the beehives are moved to the place where the flowers are, and the beekeeping is done.
- This method is suitable for landless and self-employed start-ups.
- This is because those who do not have land to cultivate flowers can keep beehives only on farmlands with the permission of the farmers.
- Good profit can be obtained by keeping and maintaining up to 50-100 hives in this method.
- Also, different types of bees are available as beekeeping is done among different crops.
- For example, neem honey is the name given to the tea collected by bees that grow near the neem tree.

Important Note: In this method, the hives should be relocated only at night.

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Location selection

- Choose a place with shade.
- All four sides need to be well lit.
- Around 2 km around the hive should be covered with trees, plants and vines. Only then will the bees get food throughout the year.
- Choose the colour of the nest of spiders near the box. Only then can bees avoid being trapped in spider webs and dying.
- And there should be no ants near the box.
- It should not be too stagnant.
- In particular, choose a place where chemical pesticides are not overused, as chemicals can affect the mental state of the bees and cause them to die.

Maintenance

- Depending on the size of the bowl in the middle of the tank, water and a little oil may be added to prevent the ants from entering the hive.
- By removing small twigs near the box, bees can avoid getting trapped in spider webs.
- Also, the beehive is located east of the beehive so that the bees' natural enemies can be avoided.
- If the bee family is weakened, a little water mixed with water can be placed near the box to encourage colonization.
- Avoid spraying perfume when approaching the beehive.
- Proper handling of bees and beehives is required.

Conclusion

An Indian beehive can yield about 5-7 kg of honey per year in standard beekeeping and up to 10-15 kg in transplanting beekeeping. By the way, beekeeping is sure to get extra income. Further information can be obtained from the nearest Agricultural Extension Center or by contacting experienced beekeepers. It is unfortunate that so many special bees are on the endangered species list.

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INDIAN LAC CULTURE – AN OVERVIEW

Article Id: AL202115

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In an agricultural country like India, along with the cultivation of crops, insects are also cultivated. Beekeeping, silkworm rearing and lac insects are cultivated under the cultivation of these insects. With the need for a little technical knowledge and less time in lac insect rearing, it can be cultivated easily. Cultivation of lac pest farming in a large scale called lac cultivation.

The term lac seems to have been derived from the Sanskrit word ‘‘Laksha’’ meaning a hundred thousand (Ogle, 2006) and is suggestive of the large number of insects involved in its production. The description of the lac insect and its host plant– Butea monosperma (Lakshataru) is recorded in the Atharva Veda. It is also mentioned in the Mahabharata that Kauravas built the highly inflammable lakhshagriha or Jadugriha (Lac house) with a motive of physically eliminating Pandavas by setting the Lac palace on fire (Chattopadhyay, 2011).

Status of Raw Lac Production

India is the leading lac producer in the world in terms of the production of raw lac, with an annual production of over 20,000 tons (Ogle, 2006). About 80 per cent of the world's total production is in India, and 75 per cent of it is exported to over a hundred countries, mainly in processed and semi-processed forms. After India, lac is produced more in Thailand. Along with these, lac is also produced in Indonesia, parts of China, Myanmar, the Philippines, Vietnam, and Cambodia etc. In India, lac production takes place in mainly restricted to the Chhota Nagpur region of Jharkhand state, Chhattisgarh state, Madhya Pradesh, West Bengal, Orissa, Uttar Pradesh and Maharashtra. Among the lac growing states, Jharkhand state ranks 1st followed by Chhattisgarh, Madhya Pradesh, Maharashtra and Odisha and the Contribution of these five states in national lac production is about 53%, 17%, 12%, 8% and 3%, respectively. These major lac producing five states contribute around 93% of the national lac production (Yogi, 2015).

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Biology of Insect In Lac Cultivation

Lac is a type of natural resin that is formed as a result of secretion by the female Indian lac insect, K. lacca (Kerr). It belongs to the Kerridae family, consists of nine genera, while the number of species reported vary from 87 to 100 species (Sharma and Ramani, 2011; Ben-Dov and Lit,). Two generas are found in India, while genus Kerria is the most important and widely exploited insect for lac cultivation in India. Lac insect is a soft-bodied, round tiny creature, which completes its life cycle in four stages viz., egg, larva, pupa and adult on host plants within six months. The adult male lac insect lives for a very short duration, such as 3-4 days, while the female lac insects live longer. During the life cycle, this insect sucked the sap juices of tree branches through its mouth, and the female lac insect secretes lac around the branches of host plants by which sticklac obtained; thus, it plays a major role in the production of lac (Ogle, 2006).

Types of Raw Lac

It is represented by two strains, i) Rangeeni strain and ii) Kusmi strain. Rangeeni strain thrives on hosts other than Kusum, while the Kusmi strain is grown on Kusum (Sharma, 2006; Mohanta, 2012). In the case of Rangeeni, two crops are such as-Katki and Baishakhi, and in case of Kusmi strain, two crops are-Jethwi and Aghani are harvested (Chattopadhyay, 2011).

Scientific method of lac cultivation

To start lac cultivation, two things are mainly to be taken into consideration, such as the suitable host plant on which the lac insect thrives and the availability of healthy brood lac in time. Major lac cultivation operations/practices consist of six stages such as i) Selection of suitable host plants, ii) Inoculation of brood lac, iii) Removal of brood lac sticks, iv) Natural enemies of lac insect**,** v) Harvesting of lac sticks and vi) Scraping of raw lac from twigs.

Selection of Suitable Host Site for Lac Cultivation

The sites for lac host plantation should be in such a place where open area, do not have fire susceptibility, free circulation of air around, the host is assured. When starting cultivation in new areas having a lac host pruned the selected host tree before infection to ensure good lac production. Selected lac hosts should have the following salient features: i)

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Fairly fast-growing, ii) Lower sap density and iii) Well adapted to pollarding. Presently 113 varieties of host plants and 87 species of lac insect have been described worldwide in which two genera and 23 species are reported from India (Sharma and Ramani, 2011). Out of which, globally followings are very common in the different region such as Dhak (*Butea monosperma*), Ber (*Ziziphus mauritiana*) and Kusum (*Schleichera oleosa*) in India; Rain tree (*Albizia saman*) and Pigeon pea (*Cajanus cajan*) in Thailand; Pigeon pea (*Cajanus cajan*) and Hibiscus species in some part of China and Nepalensis species in Myanmar.

Pruning of Host Trees

To get soft and juicy twigs in the nutritious trees, light pruning and pruning of trees is necessary at a certain time so that lac insects can be easily reared. Pruning and pruning for safflower tree is done in January-February and June-July. Pruning and pruning of the Palash tree should always be done before the new coplanes arrive in the fall.

Inoculation of Brood Lac

Brood lac is mature lac from where the young insects are ready to come out within the time specified. To achieve the best result from lac cultivation, the work should be planned in systematic manners. In order to transmit the lacquer insect to the nutritious trees, a bundle of 6 to 9 inches long, 3 to 4 stalks (equivalent to a thick ring) of the lacquer is made, which is placed at several places of the lacquer tree. This operation includes allowing young lac larvae (crawlers) to come out of their mother cells and settle on the host plant. Ordinarily, this period complete will be in two to three weeks.

Removal of Broodlac Sticks

` Used up brood lac sticks after the baby moth is released from the seed lakhs, the lakhs of stalks are called " Phunki ". Generally, the emergence of lac larvae from the brood lac ceases after three weeks. This operation should be done to prevent access of the insect predators and parasitoids of lac insect to new lac crop and to avoid wastage of lac after drying up of phunki and prevent its falling on the ground. To stop the losses of raw lac phunki, bundles are pulled down from the trees by climbing on trees or with the help of pole mounted phunki hook.

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Fig.- Pruning of Kusum tree	Fig.- Kusum tree with new leaves
	
Fig.- Inoculation of Brood lac	Fig.- Removed Phunki stick

Natural Enemies of Lac Insect

Lac insect is mainly attacked by two types of natural enemies' such as i) Parasites and ii) Predators. Parasites: these are the living organism which nests in other living bodies. It depends on their host for their nutrition, growth and development. In the case of Lac insect, small tiny winged parasites such as *Tachardiaephagus tachardiae* and *Tetrastichus purpureus* are the most abundant lac associated parasites. They lay their eggs in the lac cells and the larvae (grubs) hatching outfeed on the lac insect within its cells.on the other hand, predators which directly involved in the consumption of their host.it is more serious and can be damage up to 30-35 % the cells in a crop. *Eublemma amabilis* and *Pseudohypatopa pulvera* are the most destructive key pests of lac insect.

Harvesting of Lac Crop

Harvesting is the process in which lac collected from the host trees. Two types of harvesting process is used in most of the regions; Ari lac harvesting and mature harvesting. It is done by cutting of the mature lac encrusted twigs from the host trees. It may be of two types: i) Ari lac harvesting and ii) Mature harvesting. Immature harvesting and collection of lac before swarming is known as 'Ari lac'. In India, in the case of range lac, it is found that ari lac gives better production. Hence, ari lac harvesting is recommended in case of rangeeni only and in mature harvesting lac is collected after swarming obtained lac is known as mature Lac. The different crops have different harvesting periods. The summer (Baisakhi) and rain carpet (Katki) crop of Rangini lac, matures after 8 and 4 months of transmission respectively.

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Similarly, summer (Jethvi) and winter (Aghani) crops of Kusmi are ready in June-July and January-February, respectively. Estimated yields obtained from per tree in India are about 6–10 kg for kusum, 1.5–6 kg for ber, and 1–4 kg for dhak. The insect life cycles can produce two sticklac yields per year, though it may be better to rest for six months to let the host tree recover.

Scrapping of Raw Lac from Twigs

Scraping is a process in which incrustation lac resin removed from lac host stick. After harvesting of matured lac and sometimes immature lac is needed to be scraped as primary processing for long time storage. This practice is done with the help of a scraping knife or crusher for different applications in the processing area.

	
Fig.- Harvesting of lac	Fig.- Scrapping of lac

Composition and Their Properties

The surmised level of various constituents of lac is: resin 68 to 90%, dye 2 to 10%, wax 5 to 6%, mineral substances 3 to 7%, albuminous substances 5 to 10%, and water 2 to 3%. Lac called as multipurpose resin due to possess so many desirable properties. The important properties of lac are such as i) it is soluble in alcohol. ii) It has adhesive nature. iii) Resistance to water. iv) Possess high scratches hardness. v) It consist capacity of forming a uniform durable film. vi) it allows quick rubbing with sandpaper without gumming or slicking.

Lac and Its Forms

Lac can be obtained in different form such as Stick lac, Seed lac, Shellac, Button lac, Garnet lac and Bleached lac which is present below with their name and photographs.

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Stick lac	**Seed lac**	**Shellac**
		
Button lac	**Garnet lac**	**Bleached lac**

Uses of Lac

Lac due to unique combination of properties, lac finds a wide variety of application in manufacturing of lac bangles, glazed paper, printing and waterproofing inks, dental plates, optical frames; also used for fininshing different commercial products such as playing cards, oil cloth; and also used for preserving archaeological and zoological specimen; in the electrical industry used as coating of insulator, coating of spark plugs, cement of sockets of electrical lamp, anti-tracking insulating; in Pharmaceutical industry used in coating of tablets, micro-encapsulation of vitamins and coating of medicines; also used in automobile paint cosmetic and leather industry. Lac earlier about half of the total output was consumed in the gramophone industry. It has long been in use both for decorative and insulating varnishes, usually used as a first coating on wood to fill the pores. **Bleached lac** widely used in the coating of confectioneries and medicinal tablets. **Lac dye** widely used in India as a dye for woof and silk and skin cosmetic. **Lac wax** has widely used in the manufacturing of lipstick and shoe polishes.

Conclusion

The present text has been highlighted to expose the skill and need in the lac cultivation it will be helpful to get a superficial idea about the lac culture. The result of the present findings will not only help in understanding the life stages of lac insect during lac cultivation but will also provide an opportunity in the region to increase the plant population of suitable lac host to enhance lac cultivation as well as lac productivity in the country. Lac cultivation is the need of the day in order to preserve environmental biodiversity.

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